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A Model for Sustainability: An Implication from Social Change Agent

Khemmarat Jaroenarpharassamee, Phannaphatr Savetpanuvong

Graduate School of Management and Innovation,

King Mongkut's University of Technology Thonburi.

126 Pracha Uthit Rd., Bang Mod, Thung Khru, Bangkok 10140

Tel. +66(0)2-470-9799 Fax. +66(0)2-470-9798

E-mail: khemmarat.golf@gmail.com, phannaphatr.sav@kmutt.ac.th,

savetpanuvong@gmail.com

Abstract

This study aimed to present the concept of organizational model of sustainability by focusing on sustainability strategy, organizational structure, and systems. The concept of corporate sustainability is inspired by the real social animals, as known as eusocial, which are similar to human social systems within the organization. Bee colony and its behavior were investigated and compared to organization of human beings in management. The concepts of 5C-living are proposed, which consists of Core competence, Conservation and Construction, Coalition, Crisis resilience, and Cross generation. Complex relationships and dependencies of those dimensions are simplified and visualized into house diagram. Core competence, Conservation and Construction are modeled as a foundation of a house, while Coalition and Crisis resilience are pictorized as double pillars. The pillars are to support the driving forces from both internal and external to the organization. Cross-generation is designed as the roof to cover the last generation to generation. The house is an interdependency of the internal and external factors. Our model was validated with academic experts and industrial practitioners in multi-disciplines from both natural science, computer science, and social science. Industry experts are from leading organizations listed in Dow Jones Sustainability Index (DJSI); the well-regarded institution in ranking sustainability of organizations around the world. The results of this research will be the guiding approach for organizations from different backgrounds to apply for their sustainability objectives.

Keyword: Sustainability / Sufficiency Economy Philosophy / Corporate Social Responsibility / Sustainable Development / Corporate Governance

1. Introduction

1.1 Background and Signification of the Research Problem

Capitalism has its pitfall in bringing happiness to people. It pressures employees to deliver top line and bottom line with primary focus on shareholders and competitors. Natural resources and human resources are deteriorated incessantly. Therefore, corporatism finally dominates capitalism and forces all industry players to fight in a win or lose game. However, neither the nature nor the human wins. Is it the time for scholars and business person to rethink about how we manage the profit, the people, and the planet? This article proposes a management model of sustainability which can be used at micro and macro level in businesses and non-profit organizations (Burton, 2010).

2. Literature review

2.1 Sufficiency Economy Philosophy

Sufficiency economy sufficiency consists of 3 main pillars including moderation, due consideration and self-immunity. This can be integrated with enterprise business systems as follows.

1. The moderation of organization refers to the appropriateness of the operation both in terms of size, not too small or too big, but is conventionally considering its impact on the environment and in terms of timing, not too early or not too slow, but also made steps to ensure the operation is progressing without effecting themselves and others.

2. Due consideration of organization refers to consideration to carry any work carefully, indefatigably and without bias. With regard to the reason and factor of environment, so that the operation is properly undertaken. Effectiveness, benefit and stakeholder satisfaction can be met without adversely affecting themselves and others.

3. Self-immunity of organization refers to the composition of the operation to be ready for any consequences arising from changes from both outside and inside actors.

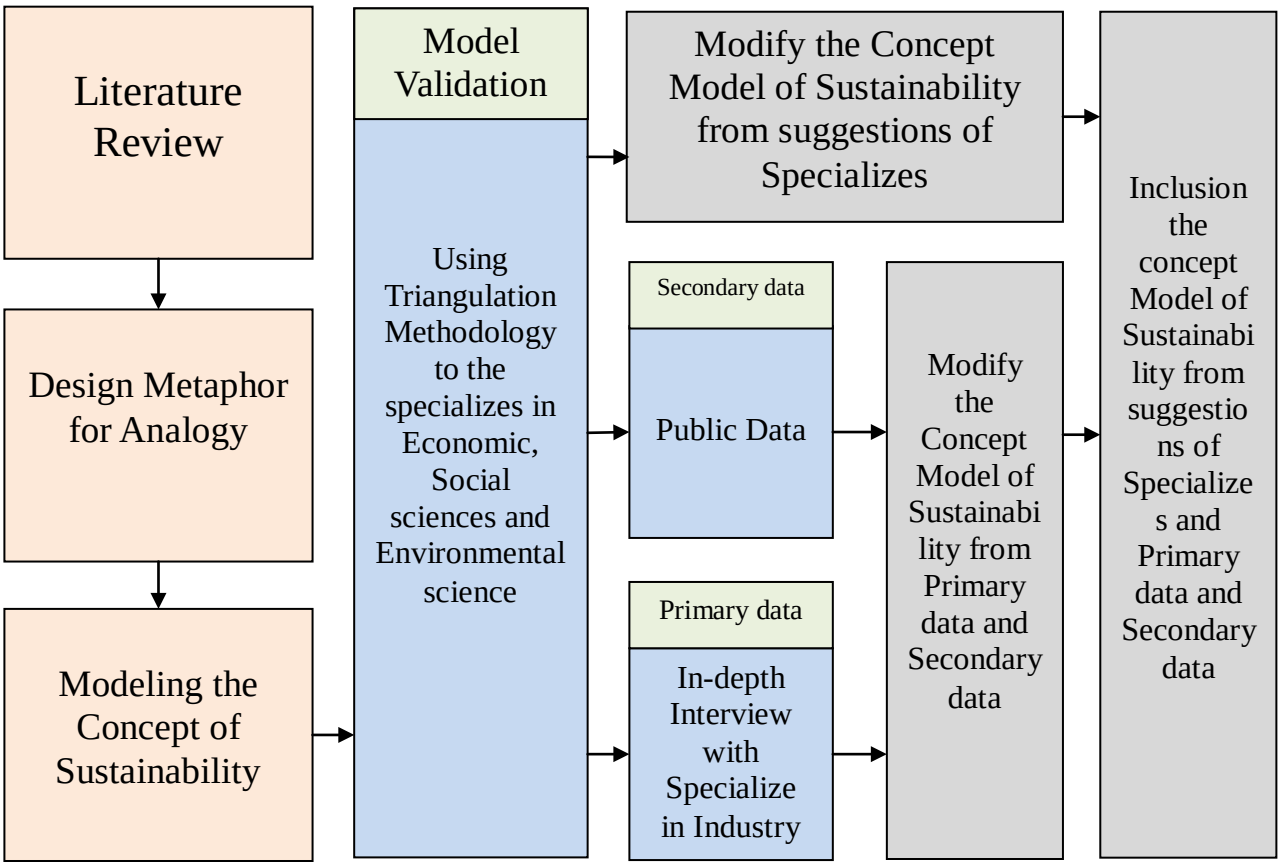
4. The knowledge and integrity in an organization means having the proper knowledge in the various academia and using it in the planning and implementation process. Operation through the primary virtue is moderation. Integrity must be juxtaposed with knowledge to achieve to organization goals optimally.

2.2 Eusociality

Refer to the organizational structure of real social insects, comprising the 4 aspects as follows: helping feed the other larvae, being a colony with a variety of models, collaborating to find food and the division of labor according to ability to inherit. In entomology, scholars considered the true social animals are bees, ants and wasps which has been defined by Suzanne Batra (1968). From observing the behavior of bees in collaborating on building the nest, finding food and spawning, it demonstrated that three hierarchies exist including the queen bee, bee drone and bee females. Queen bee will lay reproductive eggs to later become larvae, serve and distribute food for the bees in the hive. Bee drone is responsible to interbreed with the queen bee and change the nectar into honey. Last in hierarchy is the female worker bees who are with nectar duty to forward to the drone, take care eggs and larvae, clean the hive and iron sting to protect colony from enemies. The worker bees, females do to others with a willingness (Voluntary Altruism). In addition, society of bees has a social mechanism that coerce sacrifice (Enforced Altruism) where the queen bee will provide less food for selfish bees.

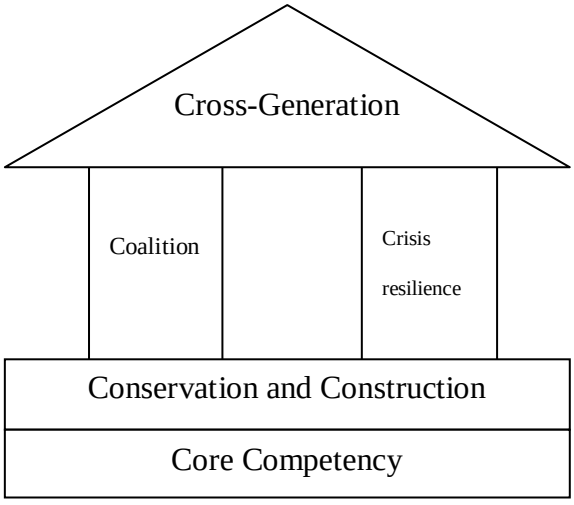
3. Research Methodology

This research is conducted with qualitative approach based up on positivism philosophy which is a study on the phenomenon of interest and curiosity. Social science techniques are used to gather primary data with in-depth interview to validate cause-and-effect model with six academicians. Content analysis is performed to adjust the model. Three case studies are researched and presented with practitioners in oil/gas industry (Eisenhardt, 1989).



3.1. Modeling

Developed on sufficient economy and behavior of social animals literature, metaphor of house is employed to propose the structure of sustainability concept which consists of 5 factors including Core Competency, Conservation and Construction, Coalition, Crisis resilience, and Cross-Generation.



1. Core competence is the knowledge of various aspects of the organization, which is due to the experience and knowledge through the exchange of people and artifacts inside and outside of the organization.

2. Conservation and Construction refers to the upkeeping of cultural and intellectual environment through the spirit of those who have sustained him/herself and others which corresponds to the concept of moderation and immunity in sufficiency economy philosophy and eusociality.

3. Coalition refers to the behavior under symbiotic society, firm must have an understanding of other stakeholders and understand itself as the main priority. This directly involves the concept of due consideration and integrity in sufficiency economy philosophy and eusociality.

4. Crisis resilience involves survival under changing society, or adaptation in a crisis situation, this aligns with the concept of immunity in sufficiency economy philosophy and eusociality.

5. Cross-generation denotes delivering something valuable to society by society of the present generation to the next generation such as environmental resources, cultural traditions and the wisdom. This concept is from moderation and immunity in sufficiency economy philosophy and eusociality.

3.2 Model validation

To prove trust and confidence in the quality of research (Trustworthiness), this research uses triangulation method to verify the content (Denzin, 1978). Four professors who specializes in economics, social sciences and environmental science were invited to verify the accuracy and reliability of this research.

3.3 Model testing

Metaphor is validated through in-depth semi-structured interviews, a dialogue that aims clear and to understand the deeper level, with experts in the organization in the top 3 Thai organizations listed in DJSI (Dow Jones Sustainability Index).

4. Results

4.1 Model Validation Results

4.1.1 Prof. A (Strategy and sustainable management)

This research has introduced the concept of the learning organization and continuous improvement (Learning Organization and Kaizen). It should link to Core Competency before delivering performance.

4.1.2 Prof. B (Society's information management and technology)

Model should incorporate an element in the "innovation" to add a new dimension of sustainability to the organization. And in practice, the idea that represents entropy or disorder, which can probably explains the phenomenon of change in management system of the organization.

4.1.3 Prof. C (Biologically inspired computing)

Model uses a house as a representative of the organization. It is the knowledge and commitment to the environment that was built as two pillars to co-exist with the environment and adapt to survive as biological living. Refer to the ultimate goal of sustainability, it is to manage the generations to go on for later period.

4.1.4 Prof. F (Economics experts)

House concept and its elements are all agreed. This knowledge is the basis of self-development similar to the animals that sustain its society by playing their roles in different ways. Most firms today is lack of "Cross-Generation" attributes even though new entity like social enterprise because most social organizations do not last long (Chell, 2007).

4.2 Model Testing Results with Case Studies

4.2.1 Company A

Company A is an organization focused on developing the potential of individuals within the organization, which company A realizes that personnel within the organization must be an example to his/her society. Therefore, the sustainable development of the enterprise should start from inside and have to start from employees at all levels.

4.2.2 Company B

This model of sustainability is more suitable for individual reference than enterprise level. However, creating a great organization should start from individuals so the model of sustainability is long term goal and mission.

4.2.2 Company C

Sustainability initiatives must start from the ability of employees and community lives first. So all corporate efforts are to create sustainability for employees and its stakeholders**.**

5. Conclusions

5.1 True sustainability must start with ourselves by learning the development of ideas and spiritual development.

5.2 Continuous organizational development to be a learning organization is the foundation of sustainable development. It should embrace a learning environment both inside and outside of organization and adaptive in time.

5.3 A good organization can succeed in finance but a great organization can succeed in finance, society and environment

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A Reduction in Environmental Degradation and Disaster Vulnerability through Sustainable Urban Planning

Ajay Vikram Ahirwar[1] and Dr. Samir Bajpai[2]

[1]Assistant Professor, Department of Civil Engineering, National Institute of Technology, Raipur, India, email: ajayvikram2002@rediffmail.com

[2]Professor, Department of Civil Engineering, National Institute of Technology, Raipur, India, email: sb@nitrr.ac.in

Abstract

In Indian cities, most of the growth in urban areas has been haphazard, resulting in environmental degradation all around, and over all poor living conditions, and an increased proneness and vulnerability to disasters. Through this paper, an attempt has been made to link the various problems with the urban growth patterns in some Indian cities. The paper also presents an alternative sustainable approach to planning future urban development, so as to reduce these problems and enhance the living conditions.

Keywords: Urbanization, Urban Planning, Sustainable, Environmental Degradation, Disaster

Introduction

Urbanization is increasing in both the developed and developing countries. Half of the world's urban population now lives in Asia. This region has accounted for 65 per cent of the demographic expansion of all urban areas across the world since the beginning of the 21st century (UN Habitat, 2012-13).In the recent past Delhi and Shanghai have joined the league of 'meta cities', having population more than 20 million people. It is expected that by 2020; another three Asian cities Beijing, Dhaka and Mumbai will have reached the 20 million figures (UN Habitat, 2012-13). The urban population of the world is estimated to increase from three billion in 2000 to five billion in 2030, with almost all of the growth occurring in developing countries (Amna Salman and Salman Qureshi, 2009). The current world population 7.2 billion is projected to increase by almost one billion people within the next twelve years, reaching 8.1 billion in 2025 and 9.6 billion in 2050 (UNDESA, Population Division, 13 June 2013). As a result haphazard and unplanned urbanization creates environmental degradation. Survey data reveal that inadequate solid waste disposal facilities, air pollution, noise pollution, traffic congestion, lack of public water supply and housing facilities are the main problems in the city area.

Urbanization processes are largely driven by market forces and government policies and outcome of social, economic and political developments that lead to migration of rural population towards urban areas.

Unplanned and ill-planned urbanization has been the cause of environmental degradation, overexploitation of natural resources, ecological disturbances, and social destitution. These factors turn hazards into disaster. The average global economical cost of disaster increased six-fold from 1970 to 2000 (Munich Re 2001). The increase in the cost and frequency of disaster is the direct result of human induced development. Disasters are not completely natural phenomenon. Disaster related with development that increases vulnerability to natural and manmade hazards.

Sustainable development has been defined in many ways, but the most frequently quoted definition is from Our Common Future, also known as the Brundtland Report: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Current Urban Challenges: Impact of Urbanization

Population:

India expected to become world's largest country passing China around 2028, while Nigeria could surpass the United States by 2050 (UNDESA, Population Division, 13 June 2013). The current trend in urban growth is not sustainable considering the accompanying urban challenges such as unemployment, slum development, poverty, and environmental degradation, especially in the developing countries.

According to the provisional data released by census India (2011), level of urbanization increased from 27.81 per cent in 2001 census to 31.86 per cent in 2011 census and growth rate of population in rural and urban areas was 12.18 per cent and 31.80 per cent respectively.

A comparative study on population growth pattern of two Indian cities Delhi and Bangalore has been presented juxtaposed against the various parameters defining the sustainable development.

Table 1: Urban and Rural Population of Delhi (Census of India 2011)

Description	Rural	Urban
Population (%)	2.50 %	97.50 %
Total Population	419,319	16,333,916
Population Growth	-55.61 %	26.56 %

Table 2: Urban and Rural Population of Bangaluru (Census of India 2011)

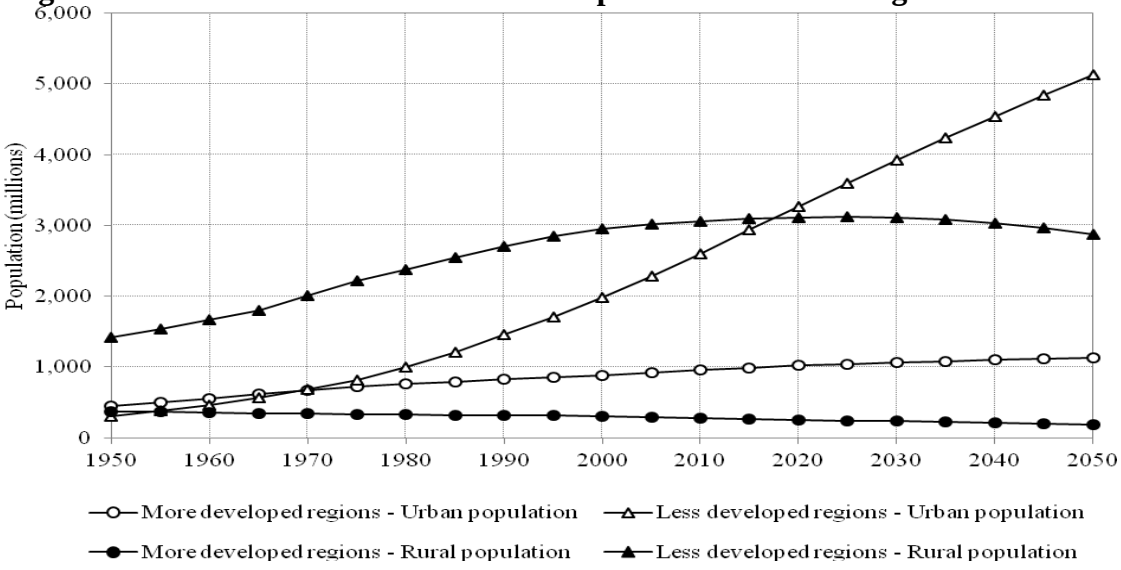
Description	Rural	Urban
Population (%)	72.89 %	27.11 %
Total Population	719,564	267,693
Population Growth	16.02%	18.60%

Table 3: Urban and Rural Population of India (1901-2011)

Year	Total	Rural	Urban
1901	238,396,327	212,544,454	25,851,873
1911	252,093,390	226,151,757	25,941,633
1921	251,321,213	223,235,043	28,086,170
1931	278,977,238	245,521,249	33,455,989
1941	318,660,580	274,507,283	44,153,297
1951	361,088,090	298,644,381	62,443,709
1961	439,234,771	360,298,168	78,936,603
1971	548,159,652	439,045,675	109,113,977
1981	683,329,097	523,866,550	159,462,547
1991	846,427,039	628,691,676	217,611,012
2001	1,028,737,436	742,490,639	286,119,689
2011	1,210,193,422	833,087,662	377,105,760

Source: Census of India in various years

Figure 1: Variation in Urban and Rural Population in various regions



(Source: UNDESA, 2012)

Environmental Pollution:

Urban atmospheric air and noise pollution are receiving attention in present years due to their adverse impact on human health and environment. As per WHO, deaths due to joint effect of air pollution in the year 2012 is 13700 people in high income countries of the Eastern Mediterranean Region, 2274500 people in South East Asia and 7054600 people in world. India contributes to 28 per cent of deaths due to indoor air pollution in the world and this is mainly because of domestic fuel burning (World Bank, 2000).

Existing problems in some Indian cities:-

Delhi:

Air pollution in Delhi is caused mainly by industry and vehicular traffic. As per WHO recent study, Delhi identified as World's worst city for air pollution. As per Centre for Science and Environment New Delhi, February 13, 2013, Delhi ranked fourth in India in the year 2010 with annual average concentration of PM_{10} found 261 ppm in 2010. Delhi is one of the most heavily polluted cities in India.

Water pollution and a lack of solid waste treatment facilities have caused serious damage to the river on whose banks Delhi grew, the Yamuna. The water quality monitoring (CPCB) results in the Delhi stretch clearly indicates the river water to be grossly polluted. The dissolved oxygen levels are practically zero at all locations except Palla and Surghat (d/s of Wazirabad barrage) (State of Environment Report Delhi, 2010).

A survey by the Central Pollution Control Board and the All India Institute of Medical Sciences showed that a majority of people living in Delhi suffered from eye irritation, cough, sore throat, shortness of breath and poor lung functioning.

In Delhi water treatment capacities have increased from 42 MGD (Million gallons per day) in 1951 to the 785 MGD. Despite this, the average shortfall is about 200 MGD (Economic Survey for Delhi, 2008-09).

About 4390 slums with approximately 5.77 Lakhs households were estimated to be in existence in urban Delhi in 2008-09. Out of 4390 about 78 percent of slums were built on public land and about 20 percent slums did not have any latrine facility (Urban Slum in Delhi 2010, Govt NCT, Delhi).

Bangaluru:

According to BWSSB the drinking water requirement of the city is 1219 MLD, while only 870 MLD are being supplied. Bangalore is prominent among the World's fastest growing cities. Due to unorganized and un-scientific growth over the last few years drinking water problem has crossed danger limits (State of Environment Report, Bangalore, 2008).

Bangalore holds the title of being the asthma capital of the country. Studies estimate that 10 per cent of Bangalore's 60 Lakh population and over 50 per cent of its children below 18 years suffer from air pollution- related ailments (Dr Parmesh, Indian Journal of Paediatrics, 2006 and State of Environment Report, Bangalore, 2008).

According to findings of National Family Health Survey in Karnataka (NFHS, 2005-06), only 71.2 per cent of the urban population use piped drinking water and only 82.7 per cent have access to toilets (UNHSP, 2012).

Among the metropolitan cities, Mumbai ranks first in E-waste generation followed by Delhi and Bangalore. Bangalore generates about 8000 tons of E-waste per year (UNHSP, 2012).

Statistics show that the ambient air quality in Bangalore is deteriorating rapidly. The amount of suspended particulate matter concentration in one of monitoring station named Victoria hospital exceeded the standard limit laid down by NAAQMS. (State of Environment Report, Bangalore, 2008).

Disaster Risk Reduction: Through Sustainable Development

An estimated 97 per cent of natural disaster related death occurs in developing countries and economic losses (measured as percentage of gross natural product) are some ten times greater (World Bank. 2000-2001).

Sustainable approaches and alternative solutions

- Public Transport System: Peoples should travel by public transport to reduce traffic congestion. Traffic congestion adversely affected the environment of cities. Town planner can suggest rapid transport facilities to the local government for preventing vehicular pollution.
- Urban agriculture: Urban agriculture has increased the food security of urban dwellers, and has reduced the need for storage and transportation.
- Secure Land Tenure: Secure land tenure for the urban poor in developing countries prevents slum formation.
- Rural Employment and Infrastructure: Better job opportunity should be generated for rural population for preventing urban migration.
- Community development funds: Community development funds are designed to provide financial resources to low-income communities.
- Strategic Planning: Compulsory rainwater harvesting in new area development and Environment protection around solid waste disposal sites.
- Good governance in action**:** Proper implementation of rules and regulation laid down by Government of India.

Vulnerability Reduction to Disaster:

We can reduce the vulnerability to disaster by adopting following principle.

- Community Participation: Risk due to disaster can be reduced by formation of various groups, having specific type of responsibility during disaster.
- Public Policy Action: Government has the responsibility for protecting the life of people and their property. Government should take suitable measures for mitigating disaster and their adverse impact.
- Safer Construction and Urban Planning: Micro-zonation and risk mapping can be important tool for reducing possible risk due to disaster. Construction should not be allowed in flood prone area and area having the possibility of landslides and construction should be done according to provisions given in respective code in earthquake prone area.

- Culture of Prevention: Prevention is always better than cure, it is better to develop a culture of prevention for reducing the vulnerability to disaster.

Reduction in Environmental Degradation and Disaster Vulnerability:

We can reduce the environmental degradation and vulnerability to disaster by adopting and considering following given tools.

Tools	Explanation
Environmental Impact Assessment (EIA) and Legislation	• EIA should be done for all type of project. • EIA helps in mitigating negative impacts, or finding alternatives, and improving project.
Geographic Information Systems (GIS) and its application	• GIS application can be helpful for disaster management and rescue and relief operation. • Maps and data can support land-use planning, risk and vulnerability assessment, disaster forecasting, and hazard management.
Land use planning	• Zoning (such as residential, commercial, industrial, etc.) and enforces standards and codes for buildings and other structures
Sustainable Development	• Solar lighting • Rainwater harvesting • Eco-friendly material • Energy efficient building • Green building concept • Recycling and reuse • Electric cars
Infrastructure and facilities	• Efficient transportation system • Solid waste management • Water supply and sanitation • Water treatment plant and water distribution system.

Conclusion:-

In this paper we have discussed the adverse impact of urbanization with examples of some Indian cities. For better urban planning and sustainable development various tools and measures are provided for developing a sustainable city and for reduction in environmental degradation and vulnerability to disaster. Various tool and measures will be helpful to city planner for sustainable urban planning. Comprehensive land use planning and revision of planning standards and administrative procedures would, go a long way to; reduce many of the problems that face urban populations in the developing areas.

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ANALYSIS OF A ROTATING ELECTRIC MACHINE MADE VIA POWDER METALLURGY APPLIED TO WIND TURBINES

Diego Pacheco Wermuth[1]
Monir Goëthel Borba[2]
Felipe Guimarães Ramos[3]
André Carvalho Tavares[4]
Lírio Schaeffer [5]

[1] MSc student in Programa de Pós-Graduação em Engenharia de Minas, Metalúrgica e Materiais (PPGEM). Laboratório de Transformação Mecânica. (LdTM), Depto. de Metalurgia, UFRGS, Porto Alegre, RS , Brazil. diego.wermuth@ufrgs.br

[2] MSc student in Programa de Pós-Graduação em Engenharia de Minas, Metalúrgica e Materiais (PPGEM). Laboratório de Transformação Mecânica. (LdTM), Depto. de Metalurgia, UFRGS, Porto Alegre, RS , Brazil. monir.borba@ufrgs.br

[3] MSc student in Programa de Pós-Graduação em Engenharia de Minas, Metalúrgica e Materiais (PPGEM). Laboratório de Transformação Mecânica. (LdTM), Depto. de Metalurgia, UFRGS, Porto Alegre, RS , Brazil. felipe.guimaraes@ufrgs.br

[4] Professor at Instituto Federal Sul rio-grandense IFSul – Campus Sapucaia do Sul
PhD student in Programa de Pós-Graduação em Engenharia de Minas, Metalúrgica e Materiais (PPGEM). Laboratório de Transformação Mecânica. (LdTM), Depto. de Metalurgia, UFRGS, Porto Alegre, RS , Brazil. andre.tavares@ufrgs.br

[5] Prof. Dr. -Eng. Coordinator of Laboratório de Transformação Mecânica (LdTM), Depto. de Metalurgia, PPGEM, UFRGS. Av: Bento Gonçalves, 9500. CEP: 91501-970, Porto Alegre, RS, Brazil. schaefer@ufrgs.br

ABSTRACT

The present paper aims to analyze the functioning of a three-phase synchronous rotating electric machine with a rotor core and stator obtained from the powder metallurgy that could be used in wind turbines. Actually the core of rotating electrical machines is manufactured using sheet metal of low carbon steel or silicon steel, requiring many processes to be done. The powder metallurgy is a manufacturing process that allows obtaining parts with close to 95 % of the final geometry dimensions, often eliminating subsequent manufacturing processes. Furthermore, using as raw material the metallic powders obtained from the recycling of metallic materials such as remnants of old cars and stamping, among others. The performance of electrical machines with different configurations was examined, alternating with two assembly components obtained by powder metallurgy and conventional method. The assembly with only components made by powder metallurgy presented a pulsating torque, which was minimized with the inclination of the slots of the stator core. Another test was done to compare the different ways of assembly of the electric machine.

Key words: Powder metallurgy; Wind turbines; Stator core; Electrical performance.

1 INTRODUCTION

The development of rotating electric machines (electric motors) more efficient, are at the limit of its improvement regarding the topology of the motors and the actuator. From the finite element software as it is possible to more optimized design of electrical concerning its geometry as the forms of rotor, stator slots, and other engines. Likewise, the use of drives from semiconductors (transistors, thyristors) resulted in inverters and converters suitable for the motors, also resulting in better performance of the machines. For this reason, a higher yield of electric motors, will be possible only with the use of completely new concepts and materials. A better performance of an electric motor, is the power developed in the reduction of losses or manufacturing cost, can be obtained by replacing certain materials conventionally used by other top performers [1, 2].

The outlook indicates that magnetic sinter obtained from a transformation metallurgy process called Powder Metallurgy (P / M), can be used in the construction of electric machines-phase alternating current, driven by static converters. Thus, magnetic materials alloy soft produced from iron powders with other elements such as phosphorus, silicon and nickel, may be used in three-phase synchronous electrical machines or even multi-phase, in the construction of the stator and rotor cores, usually obtained from-rolled steel. It is noted that certain nuclei of small engines (or micro motors) already have some magnetic parts constructed from sintered materials [3]. Sector companies already manufacture powders of high magnetic permeability, also known as microencapsulated, for use in the stator and rotor cores of electrical machines. These powders are made from ferromagnetic high permeability alloy, where the particles are surrounded by resin, and the most employed, thermosetting. The resin has two functions: to unite and make electrical isolation of the powder particles . However, currently not yet know the power engines ranging from 1 hp (or greater), built on an industrial level [3].

Surveys show that the use of sintered material in electrical machines should give the same performance characteristics and better performance in addition to simplify and cheapen its manufacturing process. The machines built on this technology can be applied to advantage in a large number of electric variable speed, such as refrigerators, washing machines, pumps, fans, cars, drives, etc. . Serving a growing market demand [4, 5].

Given the characteristics of sintered materials, you can get yourself lighter and with higher incomes machines, providing significant energy savings. The power range of up to 1 hp motors, include the vast majority of single-phase motors produced in Brazil (about 96%, according to data from ABINEE - Associação Brasileira de Industrias Electro - Electronic) and a significant portion of three-phase motors (33%, according to ABINEE). It is observed that the performance of this engine range is quite low, on the order of 40% for single and 70% to 80% for the three-phase [6]. Using sintered materials and enabling the engine to a speed control by means of a static converter, it must submit a yield above 90%. Engines developed by this technology can replace engines conventional manufactured with plates in a variety of applications, such as home appliances, cars, motors for industry, where so far the predominant use of induction motors without speed control or DC motors and AC Brush. One application is of great interest in wind turbines, since, from the drive proposed, they may advantageously replace the traditional ac motors [4, 5].

The prospects are even more interesting, when viewing the chance to build electrical machines with all magnetic parts obtained from the M / P, as a synchronous electric machine with stator core, rotor and sintered housing, and magnets permanent high-energy product to replace the field windings. A constructive advantage of this type of machine, would suit the magnetic alloys sintered of cores of the stator and rotor, the shape and form of the magnets used, addition to build, stator and housing in one piece [3].

The use of synchronous motors (AC motors) with sintered cores and permanent magnets , will surely accelerate the replacement of motors (DC motors) for AC motors. The main advantages of a three-phase AC drive in relation to a drive with traditional DC machine are as follows:

• Reduced maintenance, since there is no commutator and brushes
• Possibility of continuous and smooth variation of speed
• Less Weight
• Increased efficiency
• Cost compatible with DC motor
• Increased power / weight ratio

Due to the above advantages, there is a very great interest in developing new types of machines and materials that can be used in AC drives. The prototypes presented aim to develop a viable alternative for AC drives, you enjoy not only the technology available for manufacturing materials, but also new concepts and knowledge available to the manufacturing and machine design and converter [3].

The use of sintered magnetic material synchronous motors will result in the following advantages over the use of plates:

• Less inertia
• High strength
• Reduced Maintenance
• Lower losses, leading to better performance and energy economy
• Reduced manufacturing time
• Lower production costs (when produced on a large scale) and lower cost of operation
• Torque higher for the same amount of active material
• Operation with frequency converter with rectangular current

2 POWDER METALLURGY

Parts manufactured by powder metallurgy have a certain porosity which can be controlled by factors such as the compaction pressure, sintering temperature and time, size and shape of the particles of dust etc.. The finished part has good surface finish and dimensional tolerances adequate [7]. Powder metallurgy has the purpose of making effective without melting metallic powders or non-metallic, using pressure for compression and heat through a sintering heat treatment which is carried out below the melting point of the base material of the component part or temperature allowing them to get on or near its final form ('net or near-net-shape') [8].

The basic steps that comprise the process of powder metallurgy are described below:

Obtaining powders: There are several manufacturing processes such as powder, for example, water and gas atomization, milling, "mechanical alloying", electrolysis or chemical methods, including reduction of oxides, among others [8, 9].

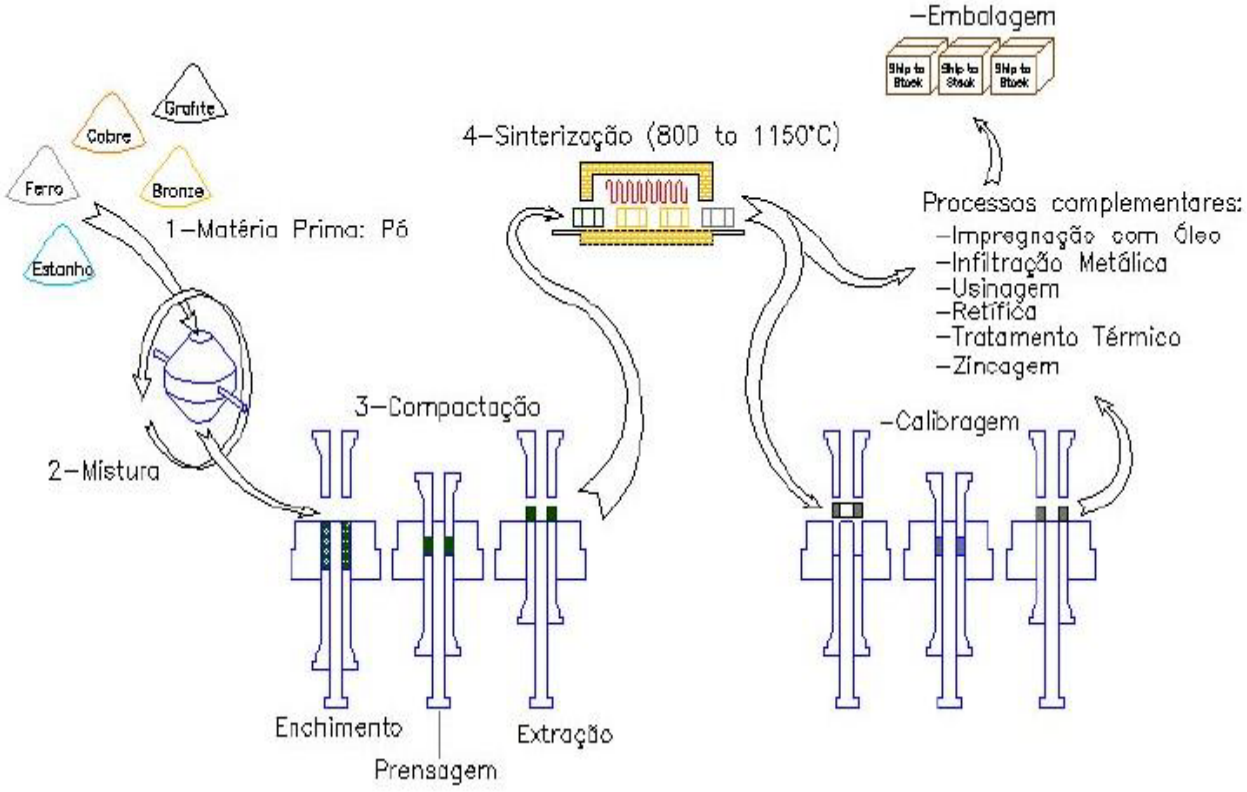
Mixtures of powders: Mixtures of various powders to produce the desired alloy and promote homogenisation of the raw materials themselves are held in the mixer for powder metallurgy or in a ball mill, is also added to a lubricant that has the function of decreasing the friction of the powder particles to each other and the friction thereof with the compression tooling facilitating the demoulding of parts [10].

Compression: Is the conformation of the powder by applying a uniaxial or biaxial pressure with appropriate tools and the approximate geometry of the finished product, generally at room temperature. In many applications where the mechanical properties are a differential, requires an increase in the density of these parts through a higher compaction pressure [10].

Sintering: It is a heat treatment that aims to provide the final desired shape reaching through chemical and mechanical properties of atomic bonding between neighboring particles. This process occurs at a temperature below the melting temperature of the base metal or the alloy considered, under controlled temperature, time and atmosphere (9) conditions [11].

Additional operations: may be aggregate a number of other additional manufacturing operations and / or finishing to improve the properties and dimensional accuracy of the sintered product, or require special features for specific applications. The recompression, resinterização, forging, calibration, metal infiltration, heat treatment, machining, tumbling and soak in oil for lubricating bearings are other steps that can be added in the production process [12].

The process of Powder Metallurgy can be seen from the schematic and simple manner in Figure 1, shown below.



Figua 1 - Simplified Steps of powder metallurgy [13]

2 MATERIALS AND METHODS

The reluctance motor proposed in this paper, was mounted on the stator of a three-phase induction machine, 4-pole, 10 hp, without change in the stator winding of the machine. The rotor core, usually constructed from laminated sheet steel has been replaced by a block consisting of 5 parts of sintered alloy from a Fe1% P. To make up the blocks was developed and constructed a

matrix, shown in Figure 2. Using the array, cylindrical blocks were compacted in the form of "cookies" to compose the body of the rotor.



Figure 2 - Matrix compression for rotor parts

Compaction of "crackers" was performed at the Laboratory of Mechanical Manufacturing (LDTM) UFRGS, a 300 ton hydraulic press. The pressure used was 300 MPa.

Material was sent for sintering in a muffle furnace type, tubular (BP) triggered by thyristors with maximum temperature of 1450 º C. The oven temperature indication of this is through a display obtained from a thermocouple S. The error between the temperature inside the tube furnace and the temperature is in the order indicated + - 2%, according to the manufacturer's manual . In sintering, an atmosphere of "green gas", whose chemical composition is 8% H and 89-92% of N. was used The sintering temperature was around 1120 ° C, at a residence time of 155 minutes this temperature. The heating rate was approximately 15 ° C / min, and cooling was performed slowly to room temperature with the parts inside of the oven.

During the step of sintering the pieces were kept for 40 minutes at 500 ° C to remove the lubricant. Figure 3 shows the isothermal sintering used with respective times.

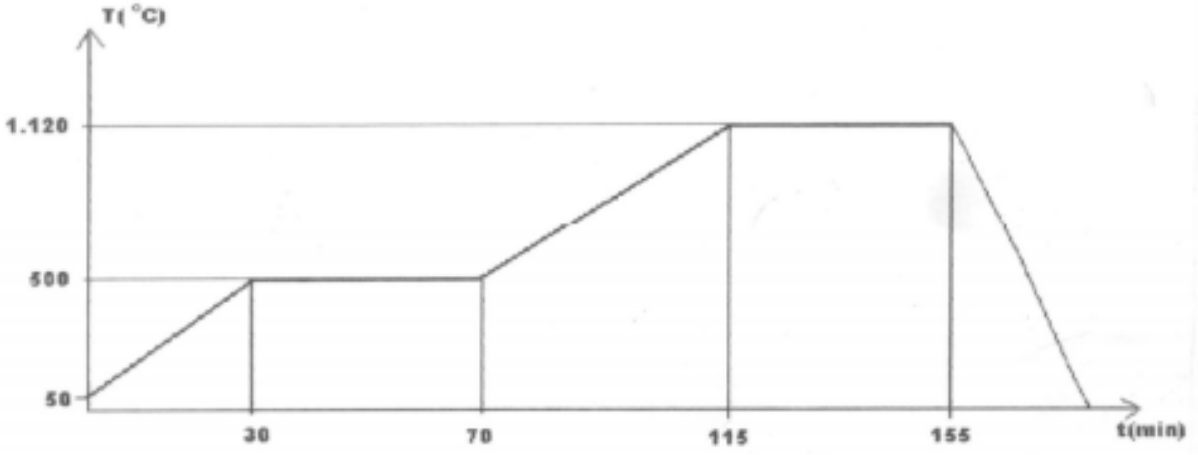
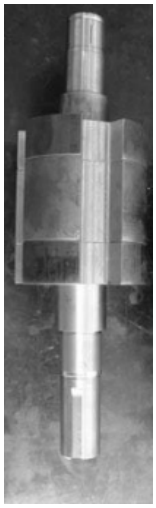


Figure 3 - isothermal sintering of samples

After sintering the samples were sent to be milled and machined to the final shape of the rotor, as shown in Figure 4.



(a) (b)

Figure 4 - (a) machined parts; (b) Rotor assembly

After assembling the parts obtained by powder metallurgy rotor, the electric machine was assembled and sent for testing performance in VOGES company, located in Caxias do Sul - Brazil.

3 RESULTS AND DISCUSSION

Performance machine tests were carried out on the VOGES company where the machine was subjected to generator test voltage, with different values at different RPM phase voltage, as can be seen from Figure 5.

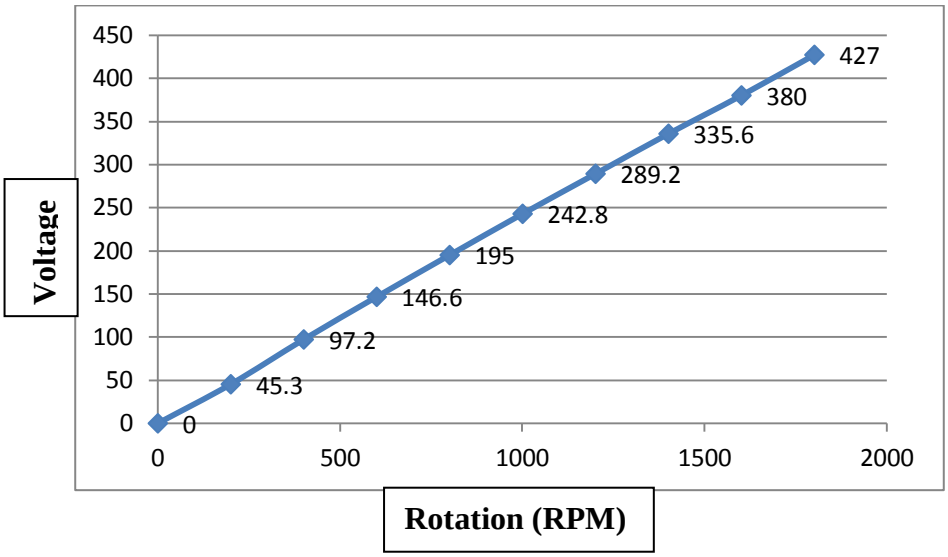


Figure 5 - Voltage (V) x RPM rotor obtained by P/M

After the acquisition of these results, a cage rotor was placed on the same stator, in order to obtain the results to make a comparison between the rotors. The results obtained by the cage rotor is described in Figure 6.

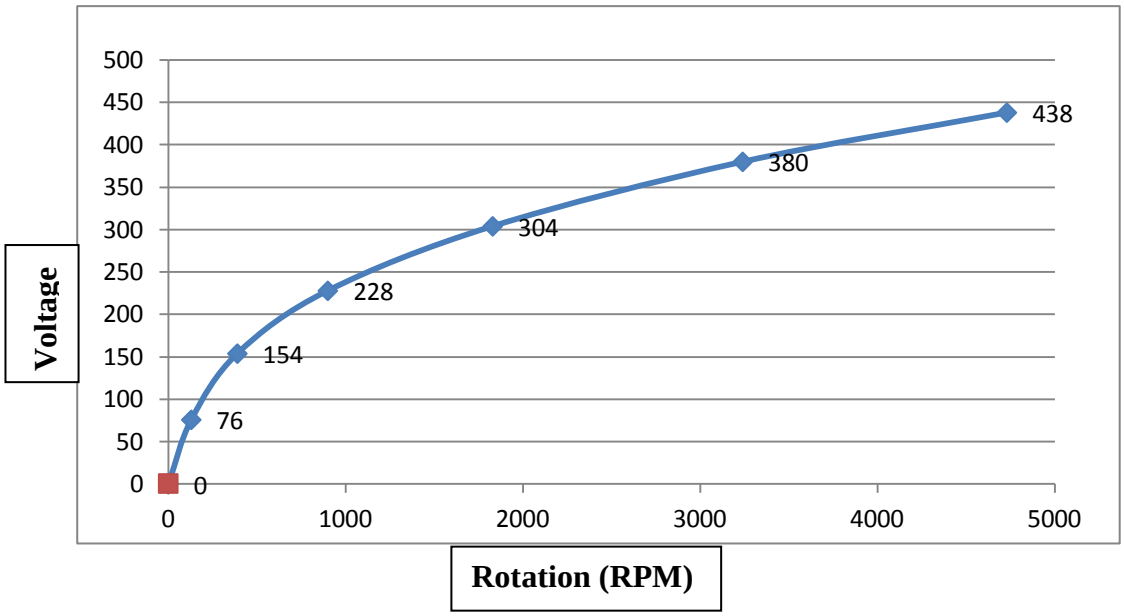


Figure 6 - Voltage (V) x RPM rotor cage

Other relevant information, is that the stator used in the tests was also obtained by Powder Metallurgy and composed by alloy Fe1% P. The stator winding is turned on in parallel for voltage 380 Volts.

For best viewing results the Figure 7 shows the voltage curves versus RPM of the two rotors.

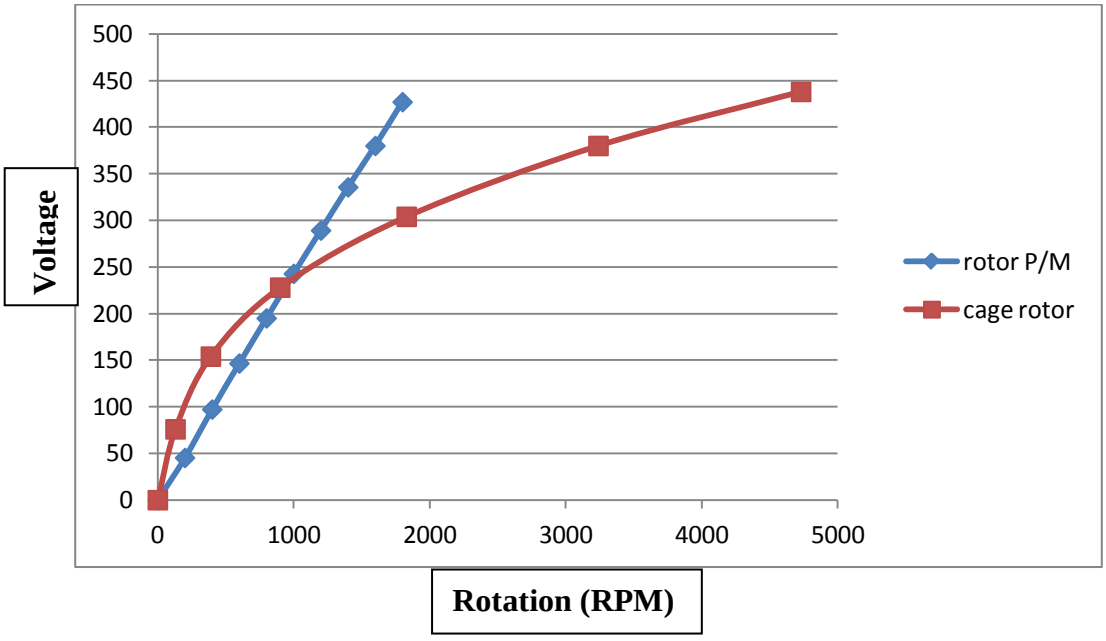


Figure 7 – Voltage (V) x RPM of Rotors

It is noted clearly that the rotor obtained by powder metallurgy reaches the same voltage as the cage rotor, but at half the rpm.

4 CONCLUSION

After analyzing the results obtained in the company VOGES and presented in Figure 7, it can be concluded that the rotor magnets showed a higher load voltage compared to the cage rotor, in considering the rotations applied.

This must be present by the magnets present a higher magnetic induction in the stator winding.

It is also seen that the stresses generated in the rotor obtained by powder metallurgy showed its peak before the half rotation of the rotor used in the next cage voltage.

The rotor obtained by powder metallurgy had excessive heating, but more studies are necessary about couplings to rotor at different stators, such as plate stators, usually used is required.

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Anthocyanins in plants at Kalasin Province, Thailand

Theeranat Suwanaruang*

*Environmental Science Program, Faculty of liberal arts and science

Kalasin Rajabhat University

Namon District, Kalasin Province, Thailand 46231

Corresponding author, e-mail: drtheeranat@gmail.com

Abstract

Anthocyanins are a group of water-soluble flavonoids that are responsible for the bright red, blue and purple colors in fruits, vegetables and ornamental crops. Anthocyanins are very spectacular plant pigments with many biological activities. However, because of their highly reactive nature, anthocyanins are unstable. The research was studied total anthocyanins from in 12 plants at Kalasin Province susch as *Amaranthus lividus*, *Syzygium gratum*, *Dolichandrone serrulata*, *Solanum melongena L*., *Solanum seaforthianum* Andr, *Lycopersicon esculentum* Mill, *Capsicum frutescens* L., *Allium ascalonicum* , *Bougainvillea glabra*, *Clitoria ternatea* L., *Brassica oleracea* L. and *Hibiscus sabdariffa* The method was extracted anthocyanins from ethanolic. The solution samples absorbed at 535 nm by spectrophotometer. The result found that the highest anthocyanic were *Amaranthus lividus* (963.97 mg/L), *Syzygium gratum*(33.37 mg/L), *Dolichandrone serrulata* (150.4 mg/L) , *Solanum melongena L*. (51.7 mg/L), *Solanum seaforthianum* Andr (286.7mg/L) , *Lycopersicon esculentum* Mil (46.53l mg/L), *Capsicum frutescens* L(188 mg/L), *Allium ascalonicum* (9.4 mg/L), *Bougainvillea glabra* (138.18 mg/L), *Clitoria ternatea* L(125.02 mg/L), *Brassica oleracea* L. (16.92mg/L) and *Hibiscus sabdariffa* (109.98 mg/L) respectively. The highest of total anthocyanins was accumulated in *Amaranthus lividus* (963.97 mg/L) and the lowest was accumulated in *Allium ascalonicum* (9.4 mg/L). Anthocyanins, members of the flavonoid group of phytochemicals, are recognised to play an important role in the enhancement of an array of bioactivities in animals, including improving vision, antioxidative activities and anticancer activities.

Keywords: Anthocyanins, plants and Kalasin

1. Introduction

Anthocyanins are a group of water-soluble flavonoids that are responsible for the bright red, blue and purple colors in fruits, vegetables and ornamental crops. The anthocyanins found in foods are glycosides of six main aglycon anthocyanidins: cyanidin, delphinidin, pelargonidin, peonidin, malvidin and petunidin. Health benefits associated with the use of anthocyanin-enriched (colored) foods include reduced risk of coronary heart disease. (Chandrasekhar Jampani, Aduja Naik, K.S.M.S. Raghavarao.2014) Fruit and vegetable flavonoids, including proanthocyanidins, anthocyanidins to an extent and anthocyanins (anthocyanidins with sugar moieties attached to the hydroxyl groups) are found in reasonably high quantities in cocoa, berries, cinnamon and red grapes and have proved to be protective against many cardiovascular risk factors. (Maria J. Kruger et al, 2014) Anthocyanins are very spectacular plant pigments with many biological activities. However, because of their highly reactive nature, anthocyanins are unstable. (Tuo Zhang *et al*, 2014)

2. Material and Method

Plants Sampling

The samples plans grabbed samples from Kalasin market that were *Amaranthus lividus*, *Syzygium gratum*, *Dolichandrone serrulata*, *Solanum melongena L.*, *Solanum seaforthianum* Andr, *Lycopersicon esculentum* Mill, *Capsicum frutescens* L., *Allium ascalonicum* , *Bougainvillea glabra*, *Clitoria ternatea* L., *Brassica oleracea* L. and *Hibiscus sabdariffa*. They were vegetables that grow and sale in Kalasin Province. (Fig 1)



Fig 1 Plants Sampling

Chemical Analysis

1. Weighting samples 5-10 g then add ethanolic (ethanol 95% : cone HCl 1% ; 98:2) 30 ml in test tube.
2. Shaking samples 30 minutes and keep samples 24 hours in dark room then measure absorbance (ABS) samples at 535 nm by spectrophotometer (Ranganna, 1977).

Final step, calculating of total anthocyanin were accumulated in vegetable samples that used this volumes formula. (S. Aubert, I.N.R.A. 1970)

Total Anthocyanin (mg/L**)** = (Abs Sample—Abs Rgt. Blank) x 470

3. Results

The result found that the highest anthocyanic were *Amaranthus lividus* (963.97 mg/L), *Syzygium gratum*(33.37 mg/L), *Dolichandrone serrulata* (150.4 mg/L) , *Solanum melongena L.* (51.7 mg/L), *Solanum seaforthianum* Andr (286.7mg/L) , *Lycopersicon esculentum* Mil (46.53l mg/L), *Capsicum frutescens* L(188 mg/L), *Allium ascalonicum* (9.4 mg/L), *Bougainvillea glabra* (138.18 mg/L), *Clitoria ternatea* L(125.02 mg/L), *Brassica oleracea* L. (16.92mg/L) and *Hibiscus sabdariffa* (109.98 mg/L) respectively. The highest of total anthocyanins was accumulated in *Amaranthus lividus* (963.97 mg/L) and the lowest was accumulated in *Allium ascalonicum* (9.4 mg/L).

4. Conclusion and Disscusion

Allium ascalonicum (9.4 mg/L) was lowest anthocyanin and the highest anthocyanin was *Solanum seaforthianum* Andr (286.7 mg/mL), Health benefits associated with the use of anthocyanin-enriched (colored) foods include reduced risk of coronary heart disease. Anthocyanins were a group of water-soluble flavonoids that could responsible for the bright red, blue and purple colors in fruits, vegetables and ornamental crops. (Chandrasekhar Jampani, Aduja Naik, K.S.M.S. Raghavarao.2014) Anthocyanins, members of the flavonoid group of phytochemicals, are recognized to play an important role in the enhancement of an array of bioactivities in animals, including improving vision, antioxidative activities and anticancer activities. The pigment anthocyanin is widely distributed in the plant kingdom and is well known to be responsible for the red, blue, and violet colours in flowers and fruits of some plants. (Haruna Kamiya et al, 2014)

After summarizing the biokinetic properties of anthocyanins and proanthocyanidins, we review basic science and clinical evidence for the effectiveness of these flavonoids against cardiovascular disease and discuss the possible mechanisms of action and cellular signalling pathways involved in this effect. Fruit and vegetable flavonoids, including proanthocyanidins, anthocyanidins to an extent and anthocyanins (anthocyanidins with sugar moieties attached to the hydroxyl groups) are found in reasonably high quantities in cocoa, berries, cinnamon and red grapes and have proved to be protective against many cardiovascular risk factors. (Maria J. Kruger et al, 2014)

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Cellulose Pretreatment Using TBAF/DMSO for Structural Transformation and Enhanced Enzymatic Hydrolysis

Deokyeong Choe and Chul Soo Shin

Department of Biotechnology, College of Life Science and Biotechnology, Yonsei University, 50 Yonsei-Ro, Seodaemun-Gu, Seoul 120-749, South Korea

Deokyeong Choe (e-mail: cd02@yonsei.ac.kr).

Prof. Chul Soo Shin (e-mail: csshin@yonsei.ac.kr).

Abstract

Cellulose is the main structural constituent of the cell wall in plants and the most abundant biopolymer in the world. The advantage of this cellulose has been leading the use of it as an alternative to fossil sources. It represents a key sustainable source of biomass for the production of transportation fuels and chemical platforms. However, the high crystallinity of cellulose makes it insoluble in water and most common organic solvents. This insolubility limits its use and prevents economically viable conversion into bioethanol. To overcome this problem, effective pretreatment is necessary, which results in the disruption of cellulose structure and improves the accessibility of cellulase. In this study, tetra-*N*-butylammonium fluoride and dimethyl sulfoxide (TBAF/DMSO) were selected as a mixing solvent for pretreatment. Rigid crystalline cellulose was structurally transformed into loose regenerated form by both dissolution in TBAF/DMSO and gel-forming process by water adding at room temperature. Then, the structural and reaction characteristics of original cellulose and treated cellulose were determined. FE-SEM images of treated cellulose displayed a smooth surface, and its crystallinity and DP were significantly reduced on FT-IR and XRD. After 48 h of enzymatic hydrolysis reaction, the conversion yield was 94% for treated cellulose and 27% for untreated original cellulose. The enhanced yield of treated cellulose is considered to be caused by the aforementioned structural transformation. These results indicate that the use of TBAF/DMSO is very effective for pretreatment.

Keywords

Cellulose, TBAF/DMSO, Pretreatment, Structural transformation, Enzymatic hydrolysis

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CO_2 taxation: Are Sterner measures needed?

Tim Kroezen

Abstract
The height of carbon taxes is under constant debate: from the low ETS carbon price of 8 $/tCO2 to taxations of 85 $/tCO2 proposed by the Stern Review. This paper calculates the additional price per barrel of various policy proposals, and compares it to the production costs and sales price of oil. Due to the OPEC arranged supply distortions prices (40-140$/bbl) are much higher than production prices (5-100$bbl). Even a CO2 tax of 85 $/tCO2 as is proposed in the Stern Review (27$/bbl) is much lower than this price difference. This gap is especially large in the cheaply produced oil, but continues to exist into the more expensive and difficult technologies, such as arctic drilling, oil shales, or gas/coal conversion processes. This paper concludes that the introduction of such a CO2 tax will still make the large majority of the available oil profitable for exploitation. This amount of oil contains more than enough CO2 to surpass the 2 degrees carbon bubble.

CO_2 taxation: are Sterner measures needed?

In 1972, the club of Rome (Meadow, Meadow, Randers, & Behrens, 1972) warned for the dangers of climate change and global warming. In spite of efforts of the environmental movements, CO_2-emissions have increased and are expected continue increasing globally. Burning all fossil fuels will likely lead to an increase in temperature of over 6 degrees Celsius, which would have detrimental consequences for the environment (IPCC, 2007). Within the scientific community there is some general agreement that global temperature should not be allowed to raise by more than 2 degrees (IPCC, 2013). Carbon taxation is often proposed as the best policy tool to decrease CO_2 emissions. This essay discusses several proposed taxation schemes and the expected effect on the amount of economically available fossil fuels. Information is gathered on estimated production costs, historical fluctuations of the oil price and proposed taxation schemes, after which the effect of taxation on economic viability is then assessed. It will be shown that the currently proposed taxation schemes are too low to prevent the carbon bubble from being breached.

The carbon bubble

No more than 565 Gigatonnes of anthropogenic CO_2 should be emitted to stay below a 2 degree temperature increase (Meinshausen et al., 2009) (Hansen et al., 2008) (McKibben, 2012). According to the Carbon Tracker Initiative globally around 2,795 Gigatonne of CO_2 is stored in proven coal, oil and gas reserves. Companies selling fossil-fuels have more potential carbon emissions on their balance sheets than what can be emitted to stay within the 2 degree raise (McKibben, 2012). These are proven reserves (1P, highly certain), meaning the minimum reasonable estimate of the amount, actual reserves are likely to be bigger. To stick to a 2 degree scenario, only a fifth of the current reported reserves of large companies can still be extracted and burned (McKibben, 2012).

An average barrel of oil contains a minimum of 317 kg of CO_2 in combustibles alone[1] (Bliss, 2008). Of course, C-content varies per type and area, and oil created from coal will emit even more CO_2 during production. When considering oil as the sole source of future emissions, only 1782 billion barrels[2] are still allowed to be emitted. As can be seen in (Figure 1) this only requires conventional oil supplies, consisting of cheaply available MENA (Middle-East & North Africa) region oil, and other countries combined. A CO_2 taxation policy would be successful in maintaining a 2 degree scenario, if it could prevent exploitation the more expensive oils (using Enhanced Oil Recovery, Arctic Drilling, bitumen, shales or conversion processes).

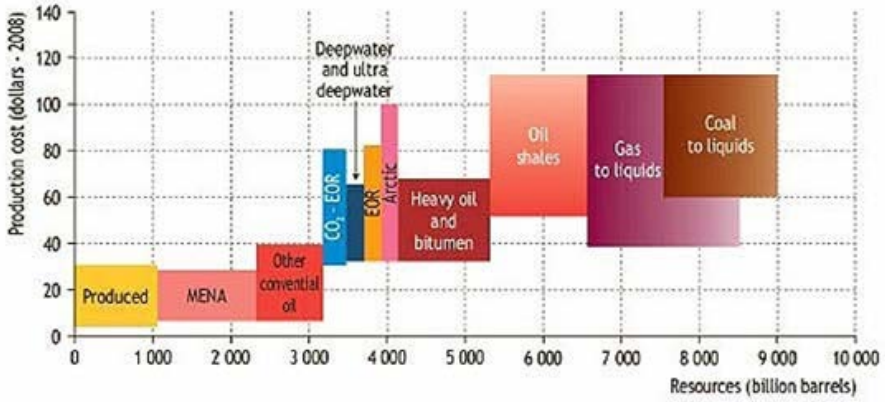


Figure 1 Reserves and the estimated production costs of Oil per type, area and method of exploitation (IEA, 2008)

Oil prices

As seen in Figure 1, the production price of conventional oil ranges from 5-40 $/bbl. However the selling price of oil is much higher. Figure 2 shows the fluctuations of the oil price from 2005 to 2013. As can be seen oil sales prices are rarely below 40 $/bbl, and have peaked as high as 140 $/bbl. By limiting supply OPEC has managed to increase the oil prices, and currently attempts are made to keep a relatively stable price at 100-120$/barrel, over the last three years this has been reasonably successful. Although it is not unlikely for oil prices to rise further, the assumption is made that there will always be a market for 120$/barrel oil. For a carbon tax to make oil consumption economically unviable, it needs to bridge the gap between productions costs (40 $/bbl) and sales price (120 $/bbl)

[1] Additional products are usually for non-energy use (production)
[2] 565 (Gtonne) / 0,317 (tonne/barrel)

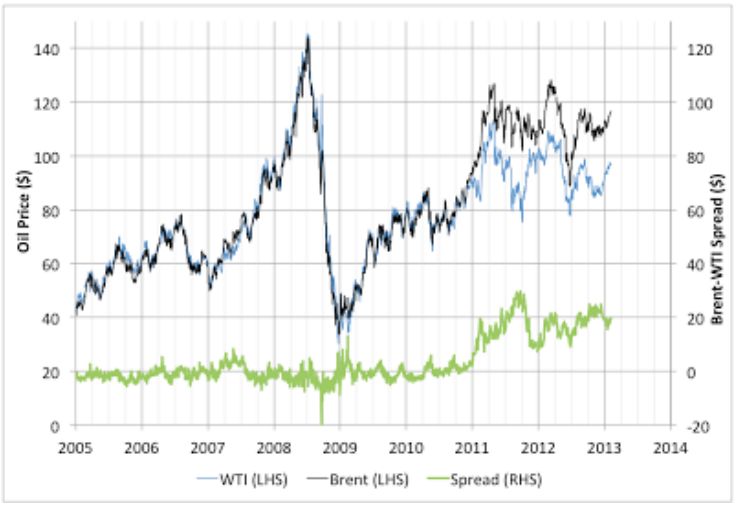


Figure 2 Historical oil price (Energy, 2014)

Carbon Taxation

One of the most famous calls for carbon taxation is the Stern Review (Stern, Britain, & Treasury, 2006), in which the potential future societal damages are calculated to be up to 314$/tC. The model has been critiqued on its low risk aversion and almost no discount rate, many claim that such a high tax would put an unfair burden on the current generation. The price is considered to be on the high end of the range. A similar model taking into account more commonly used values recalculates the value at 206 $/tC (R. Tol, Yohe, & Anthoff, 2009). Although significantly lower than the Stern review price, it hardly compares to the "general" scientific opinion. In a meta-analysis of a 103 estimates an average of 50 $/tC is obtained, well below the model proposed by Stern (R. S. Tol, 2005).

In reality the prices are much lower. The White House Estimated Social costs are (37$/$tCO_2$) and the current EU ETS is only (8.41$/ tCO_2) (Randall, 2014). Note the difference in tCO_2 instead of tC, this differs by a factor of 0,273 (12/44, C mass content in CO_2). Translating the stern review numbers to tCO_2 yields 85 $/$tCO_2$, or 56 $/$tCO_2$ for the revised version and 13,6 $/$tCO_2$ for the meta-analysis. Certain companies have been far more ambitious with their goals, surprisingly Exxon leads the board with an internal price of 60 $/$tCO_2$, companies such as Shell and Total report to calculate prices of 40 $/$tCO_2$, and even companies such as Microsoft are preparing with internal bookkeeping of 14 $/$tCO_2$ (Randall, 2014).

Every barrel of oil contains 317kg of CO_2, this means that the additional costs per barrel of oil are less than a third of the $/t$CO_2$ price. For the price mentioned in the Stern review that is 27$ per barrel extra. The commonly proposed 50 $/t$CO_2$ yields around 16 dollars, whereas the current EU ETS adds a meagre 2,5$ to each barrel in total costs. Compared to the production costs and the selling price, these taxes are very low. Also note that annual price fluctuations exceed these prices easily; *the difference in price between 2008 and 2009 prices is almost four time the Stern review tax!* Figure 3 shows an addition of the cost price, a Stern Review tax of 75 $/t$CO_2$, and the profit that could still be made, assuming a market price of 120$/bbl. For the remainder of the research the Stern carbon tax (75$/t$CO_2$) will be used for analysis.

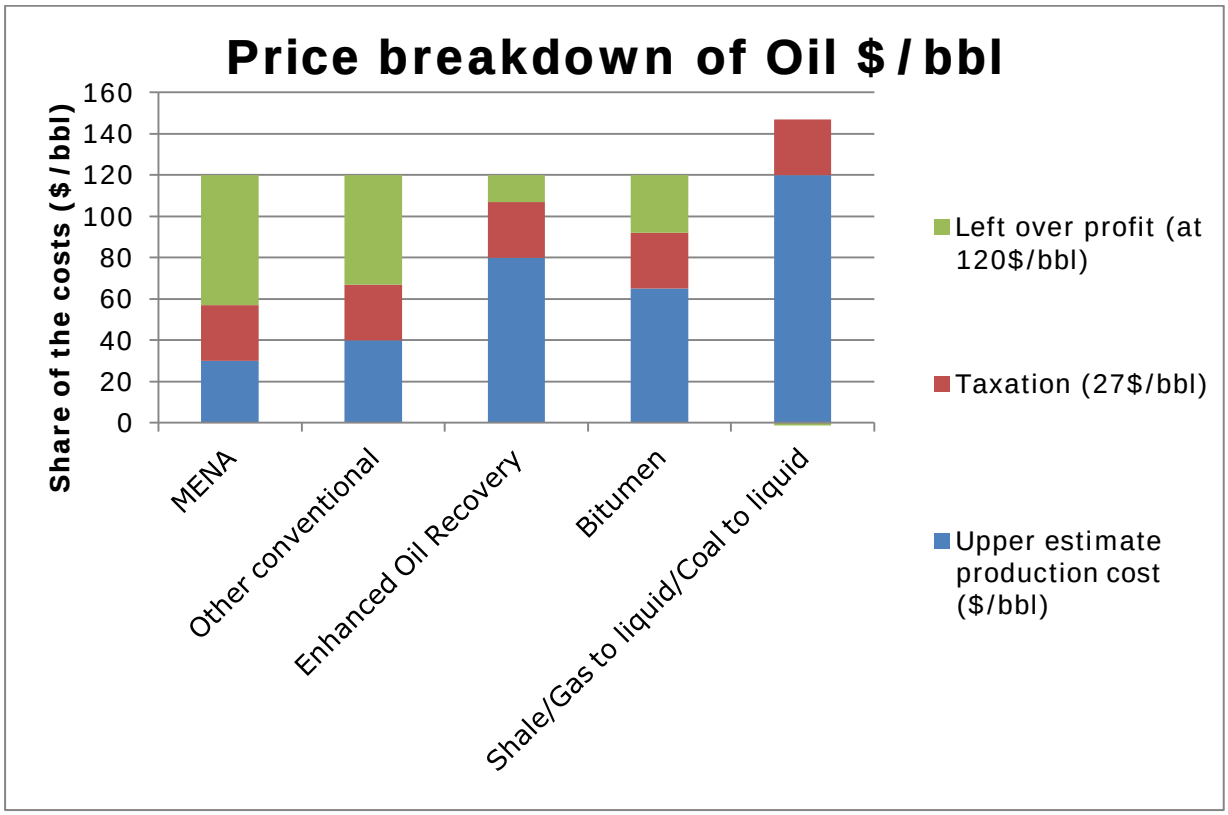


Figure 3 Price breakdown of a barrel of oil. Highest range production costs (IEA, 2008), combined with conservative oil price (Energy, 2014) and a high end Carbon tax (Stern, Britain, & Treasury, 2006). Green bars indicate sources that will remain economically available.

Shockingly a very large share of the sources remains economically viable with a carbon tax of 75$/t$CO_2$. Only the most expensive sources (oil shales and conversion technologies) might not be profitable at an oil price of 120$/bbl. All technologies below 80$/bbl are still economically available and still allow for 10% margin on sales. The reserves of the 80$/bbl sources total 4100 billion barrels of oil, or 1300 Gigatonnes of CO_2, more than twice as much as the carbon bubble of 565. From a purely economic perspective, even a carbon taxation scheme as proposed by Stern Review will not be sufficient to stay within the carbon budget.

At the current CO2 emissions of 31 Gigatonnes/year, only 18 years of current production can still be emitted in total (McKibben, 2012). Yet even Stern taxation, which is much higher than what policy makers are planning on implementing in the near future, will not be enough to prevent these fossils from being sold. Additionally there are also still large supplies of gas and coal, which will also continue to be produced and further exacerbate the problem.

Discussion

This research has only looked at the oil supply when making its predictions, and gas and coal have similar issues, which increases the problem further (although their prices are not controlled by OPEC). Additionally the assumption has been made that above a 120$/bbl no oil would be sold, whereas figure 2 shows that this has already happened in the past. Lastly this research assumes the taxes to be collected by a non-interested party. In reality large shares of fossil resources are owned

by governments, who are also likely to reap the benefits of such a tax, which means that the tax might be collected and paid by the same party. Additionally the political challenges of imposing a global emission tax is immense, considering the difficulties the ETS is already facing.

However, that does not necessarily mean that the 2 degrees goal cannot be maintained. Cap&Trade systems like the EU ETS have the potential to reach much higher prices, if the sealing is lowered appropriately. Additionally the cost of renewable production, outcompeting fossil fuels, or possibly CCS costs will drop below taxation levels. A combination of CCS development, renewable competition and a high CO_2 tax, might one day make emissions economically unviable. And although Carbon taxation might not keep us within a 2 degrees scenario, it could prevent u from reaching the full 6 degrees.

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Collective Learning Process and Community-Based Forest and Water Conservation: A Case Study in Thai Northern Village

Katesuda Sitthisuntikul
Ph.D., Environmental Management, Edith Cowan University

Current Address: Faculty of Economics, Maejo University, Chiang Mai, Thailand.
katesuda@mju.ac,th

Abstract

The approach of community-based conservation has been applied in several countries for natural resource management. This article aims to investigate an experience of this approach in Pang Jum Pee Village, Chiang Mai, northern Thailand, where a need for change was recognized, from villagers' livelihoods depending upon deforestation to ones focusing on conservation. The result indicated that the village leaders responded to ecological change through a collective learning process leading to community-based conservation. This process, supported by an external agency, convinced the villagers to realize the importance of forest and water, to carefully consume natural resources in order to support economic well-being. With its result of improving livelihoods and gaining economic benefits, the community-based forest and water conservation continued under the government's decentralization policy with the support of external organizations. The villagers expressed the need for conservation, which was itself related to a moral responsibility to protect natural resources, and in doing so indicated a sense of belonging to forest and water. The continuity of community-based conservation; however, was uncertain; it depended upon conservation concept of next leaders, awareness and cooperation of villagers, internal funding, and social conservation networking.

Keywords : Participation, Collective Learning Process, Community-Base Conservation,

1. Introduction

Community-based conservation engages with the devolution of natural resource management and responsibility from central government to local officials and local users (Agrawal & Ostrom, 1999; Fisher, 2000; Meinzen-Dick, Raju, & Gulati, 2002). The main principle of this approach is participation or a bottom-up approach to empower local communities in protecting natural resources (Brosius, Tsing, & Zerner, 1998; Brown, 2002). Specifically, it allows local communities or resource users to share problems, decisions, solutions, obligations, managements, rights, regulations, exploitations, and benefits for common natural resources (Armitage, 2005; Gadgil et al., 1993; Pagdee, Kim, & Daugherty, 2006). Subsequently, the well-being of the local community will be improved since it inspires local users to recognize the value of natural resources and an awareness of sustainable uses (Western & Wright, 1994). The term 'community-based conservation' thus involves "local-level, voluntary, people-centred,

decentralisation, and village-based management" (Little, 1994, p. 350). This practice has appeared across Africa, Asia, and the Americas for natural resource management of: forests, water, rangelands, parks, wildlife, and fisheries (Armitage, 2005; Meinzen-Dick & Knox, 1999).

In Thailand, the government has recognised environmental problems and has emphasised environmental management since the Stockholm Conference on the human environment in 1972 (Bureekul, 2007). In response to forest degradation, community-based conservation is included into national policies, laws, and programs for effective forest management similar to neighbouring countries in Southeast Asia (Li, 2002; Walpole, 1992). The national constitution and development plan allow local communities to participate in natural resource management (Rigg, 1991). The national constitution of 1997 also highlighted the importance of public participation (Ounvichit, 2005, p. 368). Article 56 stresses the right of individuals to participate in state and community work in maintaining and benefiting from natural resources and bio-diversity, and to protect, promote, and maintain the environmental quality for their normal way of living without creating danger to their health, welfare, and quality of life. In addition, to balance economy, society, natural resources, and environment, the ninth (2002-2006), the tenth (2007-2011), and the eleventh (2012-2016) national development plans have each encouraged participation of people in development and conservation (National Economic and Social Development Board, 2001, 2007, 2012).

This article aims to explore an experience with collective learning process in recovering and conserving forest and water for improving the villagers' livelihood at a Thai northern village, Pang Jum Pee, in Chiang Mai Province. A description is sought as to 1) how the leaders participated in the collective learning process; 2) how this process empowered community-based forest and water management leading to the improvement of villagers' livelihoods; and 3) how the villagers showed an awareness of conservation and what the future holds for it.

2. Research Method

Several qualitative methods were used: in-depth interview, participatory observation, focus group and document analysis. In-depth interview, however, was the primary methods used in this study. Researcher purposively interviewed the participants who were able to provide information, experiences or stories about collective learning process and community-based conservation. This

method provide direct conservation with participants, 30 to 60 minutes, in order to explore deep insiders' viewpoints, experience, ideas, thought, feelings, and perceptions (Charmaz 2003; Liamputtong 2009). To engage in activities and events in Pang Jum Village, participatory observation were combined since it allowed living in study areas and interacting with participants (Monaghan & Just, 2000; O'Reilly, 2005); observing and/or taking part in common and uncommon activities (DeWalt&DeWalt, 2011, p. 2). Informal focus groups with the leaders and villagers were also managed by chance in order to assess similar and different ideas within the same group of participants (Dalton, Elias, & Wandersman, 2007). In addition, materials or document were asked from participants; maps, pictures, letters, and diaries.

All data collected were transcribed, organized, and analyzed until a description was completed. Interview quotes are presented here, following translation from Thai to English. Ethics approval was provided by Edith Cowan University's Human Research Ethics Committee (HREC) and approval to conduct the study was granted by the Village Chief and broadcast to villagers prior to the commencement of the study.

3. Engaging with the Collective Learning Process

A dependence on timber businesses had caused deforestation and a struggle in Pang Jum Pee Village for survival from 1976 to 2002. At that time, Pang Jum Pee Village was notorious as being 'Mod Mai Tum Lai Pa' or 'deforesters'. The villagers had gradually changed their livelihoods from a subsistence resource base to a more modern base since national development policy induced them to connect with modernisation. The villagers then tended to overuse trees for timber business to gain income rather than make only sufficient use of them to serve basic household needs. Subsequently, an ecological impact of deforestation occurred that ultimately was a concern for their livelihood; the villagers struggled with the degradation of forests, loss of trees, and drought in the Mae Lai Noi stream.

National conservation policy and the awareness of struggled livelihoods by heavy deforestation; however, forced the leaders at Pang Jum Pee Village to persist with seeking a solution to the rehabilitation of water and forest sources. From 2003 to 2006, the Community Committee at Pang Jum Pee Village, the official leaders that a village leader was nominated as a chairman, participated in a project of community-based research (CBR) developed and encouraged by the

Thailand Research Fund [TRF], Community-Based Research Division. The TRF is a semi-government organisation established under the National Research Endowment Act of 1992 (Thailand Research Fund, 2010). This project emphasized a collective learning process to empower the local communities to solve and manage own problems in order to respond to the mounting local concerns or needs. As required by TRF, facilitators or counsellors were obliged to guide the collective learning process and the leaders, including the Community Committee at Pang Jum Pee Village also became investigators or researchers to participate in this process until the CBR project was completed.

> *I needed to design the research method, facilitate the learning process, and give advice or direction. We usually gave information to researchers so that they could make appropriate decisions. We also asked them what the benefits of their decisions or actions were. This role needed deep understandings about research and local context. That meant that a facilitator should engage with villagers to learn about villagers' lives and contexts.* (A facilitator or counsellor)

An analysis showed four stages of collective learning process (see Figure1): problem identification, data collection and analysis, and participatory action, including a discussion platform to share ideas and feedback on learning process collectively.

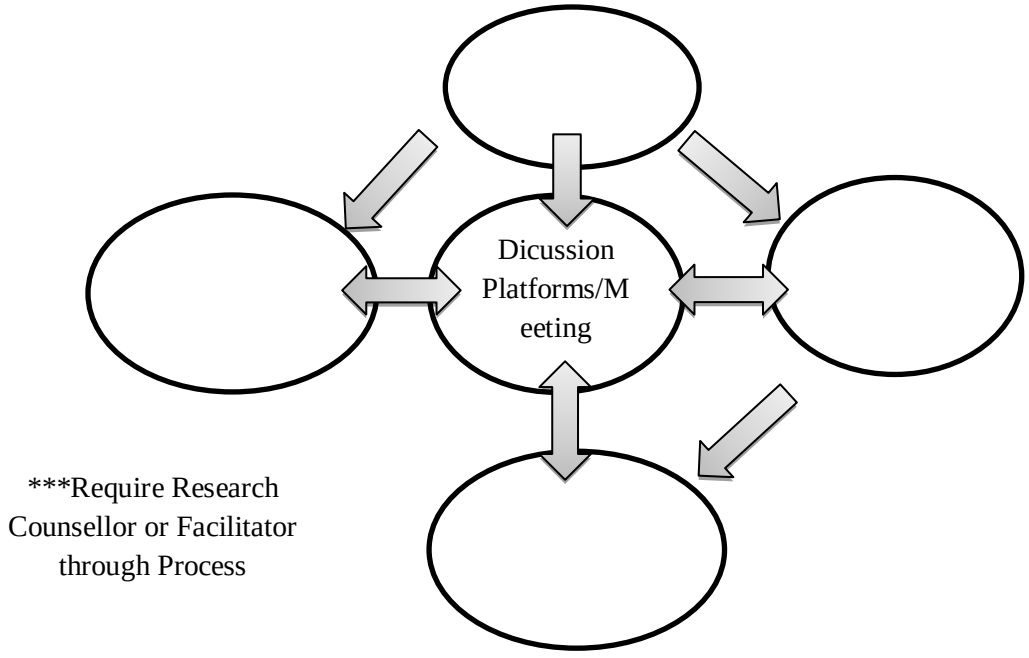


Figure 1 Collective learning process for forest and water recovery and conservation

3.1 Problem Identification

The facilitators from the TRF organised a fortnightly meeting in Pang Jum Pee Village, for three months, for discussions with the leaders or investigators. These meetings aimed to identify actual problems and formulate research questions. Asking questions was the main tool of facilitators to motivate villagers to think analytically about actual concerns in the village context. Ultimately, the team of investigators was able to prioritize problems and make their own decision as to which problems were the most important. After a long discussion, they agreed to indicate the question "how to build participation for recovering and conserving water in the Mae Lai Noi Stream".

> *At the beginning, a facilitator asked us, why did you want to do shrimp farming? Could you tell me the reason? I said I wanted to promote an occupation for villagers. Right now, cutting trees was the main occupation. We discussed about this a lot. Then, he suggested rethinking of doing shrimp farm. He asked why not think about the bigger issue such as water and forest recovery rather than shrimp farm? How shrimp could live without water?* (A village leader)

3.2 Self Reflection

A research counselor designed the activities of writing and sharing stories which was self-reflection or introspection. Each of investigators was assigned to write independently about personal stories, families, experiences, events, or the stream before sharing their narratives with other participants in a small meeting. This step underpinned profound understandings of relating themselves to village, water, forest, and other people and stimulated an awareness of the roles of self, family, village, society, and environment.

> *I wrote where I studied, who my friends were, where I used to go, how many girlfriends I had, what my workplace was, how much money I earned, and what I continuously did. Just kept writing what I already knew. Writing life story made me think about bad behaviour such as shooting animals. I thought that how my wife and kids could survive if somebody shot me. So, I withdrew from hunting.* (A member of the community committee)

3.3 Data Collection and Analysis

This step emphasised investigating facts to uncover the cause of drought in the Mae Lai Noi stream so that the leaders in the villages or newly named researchers or investigators could indicate the appropriate strategy and action for water recovery. The TRF's facilitator assisted the researchers to design data collection and facilitate data analysis in monthly meetings. In this process, two main themes were the focus, namely to understand the relationship between livelihoods, forests, and the Mae Lai Noi stream, and to seek the cause of change in the Mae Lai Noi stream. Each researcher independently selected a theme in the collection of data. For example, the first investigator preferred to gather data about the irrigation system and ceremonies in rice farming because of his farming background. The second investigator, who had knowledge about agriculture, volunteered for examining land use and agriculture at the bank of the Mae Lai Noi stream from the perspectives of the quantity of agriculture, the types of growing plants, and water uses. Another investigator wanted to survey the Mae Lai Noi stream and its tributaries in the forests because he was familiar with the forest routine.

In the data analysis, monthly meetings were organised wherein the researchers shared and discussed ideas, strategy, and plans based on data. Everybody could argue any of the findings, complete data, and suggest further data collection. At the same time, the facilitator promoted discussion, identified main ideas, and concluded further action. Ultimately, the process of data collection and analysis underpinned insights into the connection between the villagers, water, and forests. The investigators also understood the cause of drought in the Mae Lai Noi stream which informed the strategy of changing people's thoughts about recovering water and forest. People needed water and forest for earning a living but overusing trees or deforestation for timber business was harmful.

> *I thought the collective learning process helped develop analytical thinking. It made me realise that people could not survive without water. I became aware of how to keep water.* (A member of the Community Committee)

> *People, water, and forest had a close relationship. We shared and discussed information about traditional lives and water several times. Then, we came up with an idea of recovering people for water and forest recovery*. (A village leader)

3.4 Participatory action

This step emphasised building participation in forest and water recovery based on the strategy of changing people's thought processes. The team of investigators used three main techniques to stimulate an awareness of conservation: giving direct information; developing collective agreement; and performing ceremonies. The researchers provided the information they discovered from the previous step directly to villagers at Pang Jum Pee. Mainly they explained: how water and forest was important to villagers' lives, what the cause of drought was, and why villagers needed to conserve water and forest. A village leader formally educated villagers in his role as the village leader sometimes through public amplifier or at the village meeting every two or three months. The investigators also shared responsibility to talk informally with villagers.

In developing collective agreement, the research team employed a discussion platform or meeting format in the collective learning process. It allowed the Community Committee and the villagers to share and discuss ideas or plans which led to collective decision making and agreement. Before discussion with the villagers, the village leader organised a meeting with the researchers, the research counsellor, and the Community Committee, proposing determination of regulations and ideas of restrictions to protect trees and fish. Since the data indicated forest deterioration at the upper source of stream and the extinction of some kinds of fish, the regulations for cutting trees and for fishing then were drafted as follows:

- Cutting down trees for timber business was strictly prohibited. It was permitted for building a house in two cases, a house with rotting timbers and one for a newly married couple. The Community Committee was obliged to consider exceptions and violations.
- Fishing in the restricted area which the villagers called the 'fish house' was strictly prohibited. In this area, only traditional methods to trap a small amount of water animals could be used for fishing such as nets and blocking water ways. Any methods to stun water animals such as using chemical substances and electric shocks, and bombing were strictly prohibited. Any violator would be fined 5000 baht.

Interestingly, the investigators applied ceremonies based on the belief in supernatural powers to uplift the spirit of villagers for water and forest conservation. The Community Committee and the

villagers agreed with the plans of the village leader to perform the ceremonies of Buat Pa or tree ordination, and Seub Cha Ta Lum Num or longer life rituals for water. Significantly, Buat Pa and Seub Cha Ta Rum Num functioned as the centre of social cooperation. The villagers were excited and enthusiastic about participating in the performance of the ceremonies. Before ceremony day, the village leader and the Community Committee discussed with villagers in the village meetings in order to collectively prepare the ceremonial performances. Everybody shared activities and jobs, such as cleaning the village and the Mae Lai Noi stream, including preparing the site, food, belongings, and offerings. There was also an emergence of cooperation in forest and water conservation. For example, a villager gave his land (about 10 rais or 1.6 hectares) to the Community Committee for forest conservation at the upper source of the Mae Lai Noi stream. The Local Authority of Huay Kaew Sub-District, Mae On District, Chiang Mai gave support to a waterfront pavilion on the Mae Lai Noi stream, road construction to the centre of ceremony venue, and a trekking route from Pang Jum Pee to a neighboring village.

4. Improvement of Self-Management and Livelihoods

After finishing the project on community-based research in 2006, the Community Committee at Pang Jum Pee Village was in a position to continue community-based forest and water conservation to balance the use of natural resources and protect livelihoods. They had learned collectively that forest, water, and the villagers were interconnected, and that building participation with villagers based on data or facts, was a pivotal strategy to success in conservation. Before any actions were undertaken, the village leader emphasised the importance of discussing ideas, facts, and plans with the members of Community Committee and the villagers.

> *Whatever I did, I could not get the chance of success without participation. I could not act alone or command other people. I usually talked with the Community Committee before talking with the villagers. This committee could help me explain and build cooperation with villagers. If I had tried to enforce any actions or regulations without talking, everybody would have resisted me.* (A Village Leader)

There were regular activities for forest and water conservation like growing plants and trees, building fire breaks to prevent forest fires, constructing bamboo weirs to increase moisture in the

forests, and performing the spiritual ceremonies for forest and water. These activities were mostly supported by donor agencies that placed on conservation of natural resources in local communities. In addition, the Community Committee determined and enforced self regulations for forest protection based on agreement with the villagers. These regulations, for example, for land use, protected areas, and forest product control, restricted the uses of natural resources in the forests (those used for sustaining livelihoods). Importantly, the Community Committee continuously managed the Local Learning Centre of Pang Jum Pee Village since they and villagers agreed to develop it in 2006. This centre is well known inside and outside of the village and has gained recognition as a centre of education and conservation.

These continuous actions for forest and water conservation led by the Community Committee were able to improve the villagers' livelihoods; people could seasonally hunt for wildlife and collect several kinds of plants such as local ferns, bananas, mushrooms, and bamboo shoots.

> *Our forest was greener than before. Fish and crab were also more abundant. We could easily earn a living from the forests and water. We could do any jobs I wanted even though we could not get much money. It was different from cutting trees that made me feel uncomfortable. Now, I felt free, happy, and comfortable with legal jobs. I could live without destroying anything.* (A villager)

5. Sense of Conservation and an Uncertain Future

Since the Community Committee emphasised community-based forest and water conservation, most villagers had been aware of the importance of forest and water to their livelihoods. The following several ways to show cooperation in forest and water conservation were noted when some villagers were asked their opinion of conservation:

- Most villagers ceased wrongful behaviour such as cutting down trees and burning the forest so that they could rely on earning a living there.

> *I did not cut down trees or burn the forest because I wanted to conserve water and I did not want fire to burn my orchard. Forest was the place for earning a living. It gave me income. If I didn't conserve it, I couldn't sell anything.* (A villager)

- Some people educated other people who had broken the forest or water conservation regulations, or reported to the Community Committee about serious violations.

Everybody had a duty to take care of the forest despite not being employed in any formal position. Sometimes, I warned somebody who was burning forest or cutting trees. When I saw forest fire, I called the village leader or a member of the Community CommitteeI lived here! I loved the forest! So, I wanted to help keep it! (A villager)

- Generally, the villagers participated in any activities for forest and water conservation led by the Community Committee**:** growing trees, building forest fire breaks and bamboo weirs, and performing the ceremony for forest and water.

It was my duty to cooperate with leaders because I lived here. I needed to show unity as a follower. Whenever leaders asked, I went to help. Sometimes, I joined in planting trees, and doing fire breaks. I thought that I should return something to the forest because I used it a lot. I needed to sacrifice my time for collective jobs. (A villager)

- Some villagers followed a more traditional way of life to conserve water and forest. They realised that sufficient use of natural resources could sustain their lives depending upon forests.

I felt comfortable to only catch fish to eat in my family. I did not need to sell it. Sometimes, I went back home late. I brought one net with me and caught some fish. I then cooked curry fish or chilli paste. That was enough for me. (A villager)

- Educating the next generation was pivotal to the continuation of forest and water conservation. The present generation needed to teach and share their experiences: a negative one for deforestation and a positive experience for conservation.

We had to teach our children or grandchildren to become lovers of forest and water. Tell them that no one could survive without water and forest. Our coffee orchard needed water to grow. Water also gave beautiful and green trees. Big trees could hold a large amount of water. I never thought like this before. (A villager)

However, when I asked the leaders at Pang Jum Pee Village about the future of conservation, no one could guarantee the continuity of forest and water conservation. They suggested further missions for the Community Committee.

- To continue activities for forest and water conservation, the Community Committee should manage collective funding in addition to depending on external funding.

I thought conservation should rely on self funding. In some years, we could not get support from any agencies. If we lacked funding, no one would help to take care of forest. We needed to do something. (A member of the Community Comittee)

- To gain insight into and stimulate the awareness of cooperation for conservation, the Community Committee should constantly explain to the villagers, especially the younger generation, about the advantages of conservation.

In the future, we should educate the young generation at least twice a year about living in the forest. This will stimulate an awareness of young people what the benefits of conservation such as giving food. (A member of the Community Committee)

- Teaching and developing the next leaders of the conservation movement had been a difficult action to predict for the Community Committee. Without succession, the future of water, forest, and people will be less secure.

It was hard to say how water and forest would be if I and a village leader retired. Everything depended upon the next Community Committee. At least, the Local Learning Centre and regulation enforcement would exist. But I did not know about the way people will think in the future. I don't know even how people will teach their children and grandchildren. Our future depends upon young people but it is difficult to convince them to join us. The life of young people has moved to follow globalisation. Developing young people will be problematic. (An assistant village leader)

- The village leader strongly believed that water and forest conservation was a cross-boundary issue. It needs cooperation among other villages in the same district. He expected to connect a social network for further success of water and forest conservation.

I thought of the future. If every place took care of environment, no one will be worried about flood or drought, and the national issue could be solved. I always say to other people that even though Pang Jum Pee villagers hadn't burned the forest, we still had problem with forest fire. Other villagers burned forest and that made us concerned about the possibility of forest fire spread. So, it should be better to work together. I would like to build a strong conservation network in our district using the collective learning process.(A village leader)

6. Discussion and Conclusion

When natural resources were depleted or degraded, humans find themselves in a situation where continuing their activities to survive, economic growth, and development was limited (Hardin, 1998; Meadows et al., 1998). This study argues that the damage done to pivotal natural resources**,** especially water, constituted the awareness of leaders to lead a community-based, or participatory, forest and water conservation to reconnect villagers' sense of belonging. This participatory approach emerged when external agencies began influencing the villagers; a trend towards an environmental consciousness that challenged communities to manage natural resources based on decentralisation of authority away from central and other government administrative levels to local communities or local resource users (Agrawal & Ostrom, 1999; Kumar, 2005; Strum, 1994; Twyman, 2000).

Brown (2008) and O'Brien and Williams (2007) agreed that collective thinking and action is a key to weaken the complex and interconnected bonds of economy, society, and environment for human sustainability in the era of globalisation. In the global environmental movement, there has been an extensive contribution by community-based conservation according with the concept of sustainable development and the call for action of Agenda 21 (Campbell & Vainio-Mattila, 2003; The World Commission on Environment and Development, 1987; United Nations Conference on Environment and Development, 1994). The participatory process allowed people to share knowledge, skills, and resources, constituting a more effective pattern of conservation (Barton, Borrini-Feyerabend, Sherbinin, & Warren, 1997). Importantly, it is a practical approach for: stimulating a sense of forest and water problems and cooperation in conservation; empowering creative thinkers and lifting the ability of self-reliance; and developing local institutions for conservation. However, Western (1994, p. 449) wrote that "the success of community-based conservation will depend on outside forces and how conducive they are to the growth and spread of conservation within and between communities". Pagdee, Kim, & Daugherty (2006, p. 49) argued that three factors of success in community-forest management are "well-defined property rights, effective institutional arrangements, and community interests and incentives".

Hence, stimulating a sense of being a part of natural resources required an empowerment tool such as the collective learning process that constituted community-based conservation for

sustaining natural resources and livelihoods. The continuity of forest and water conservation , however, required further robust effort by the Community Committee to develop the next conservation leaders, stimulate awareness and participation inside the village, connect social conservation with networks outside the village, and manage internal funding that supported conservation activities.

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DESIGN AND IMPLEMENTATION OF A HIGHER CERTIFICATE IN RENEWABLE ENERGY TECHNOLOGIES IN AN UNIVERSITY OF TECHNOLOGY IN SOUTH AFRICA

Pierre E Hertzog, Herman J Vermaak, Johan H Raath
Department of Electrical, Electronics and Computer Engineering,
Central University of Technology, Private Bag X20539, Bloemfontein, South Africa,
Email: phertzog@cut.ac.za

ABSTRACT

The Department of Electrical, Electronic and Computer Engineering of the Central University of Technology (CUT), Free State has implemented a Higher Certificate in Renewable Energy Technologies (HCRET) in January 2014. This is the first pre-graduate course in renewable energy that was approved by the South African Qualification Authority (SAQA). There is currently a significant drive for establishing a range of alternative energy technologies, with solar and wind energy in the majority, ventures that is backed by government and industry in South Africa. The need has thus arisen for technical capacity to back up the implementation of these innovations both in rural and urban contexts. The HCRET was designed for those individuals that want to enter the renewable energy field as technicians. Successful completion of the Higher Certificate in Renewable Energy Technologies is a way for the successful students to demonstrate that they have achieved a basic knowledge of the fundamental principles of the application, design, installation and operation of Photovoltaic (PV), Solar and Small Wind energy systems. This qualification can also assist in strengthening an individual's profile for articulation towards entering an engineering qualification at the Central University of Technology, Free State. In this paper, all the considerations and challenges in the design and implementation of this HCRET qualification will be discussed. The paper will also cover the decisions made in terms of the selection of subjects for this one year course in Renewable Energy at the CUT.

1 INTRODUCTION

The Central University of Technology, Free State (CUT) main campus is located in the city of Bloemfontein, Free State province, South Africa. In 1981 the CUT, then known as the Technikon Free State, opened its doors with 285 students enrolled in mainly secretarial, art and design programs. Over the past 33 years the CUT has developed into a leading institution able to take its place in the national and international higher education environment. The current total student population is more or less 12000. Each annual intake is approximately 3,000 students, of which three quarters from the Free State. Approximately 2,000 students graduate annually.

The CUT is home to twelve departments arranged in four Faculties: Humanities (including Education), Health and Environment, Management Sciences, and Engineering and IT.[1]

The Department for Electrical, Electronic and Computer Engineering forms part of the Faculty for Engineering and Information Technology. This faculty contains the following departments:

- Department of Civil Engineering and Built Environment
- Department of Electrical, Electronic and Computer Engineering
- Department of Mechanical and Mechatronic Engineering
- Department of Mathematical and Physical Sciences
- Department of Information Technology

All programmes have been offered now for more than 25 years and meet the requirements of both the university and the Department of Higher Education.

The Department of Electrical, Electronic & Computer Engineering offers courses in Electrical Engineering: Light Current and Heavy Current as well as Computer Systems Engineering. These courses deal with the study and application of electricity, electronics, electrostatics and electromagnetism – which covers a range of sub-studies including power electronics, control systems, signal processing and telecommunications.

Higher Certificate: Renewable Energy Technologies
National Diploma: Engineering: Computer
National Diploma: Engineering: Electrical (Light Current)
National Diploma: Engineering: Electrical (Heavy Current)
Baccalaureus Technologiae: Engineering: Electrical
Magister Technologiae: Engineering: Electrical
Doctor Technologiae: Engineering: Electrical

CUT's strategic direction is set by Vision 2020. CUT has sought to implement this vision in respect of its curricula and support mechanisms through the process of STEPS, the Strategic Transformation of Educational Programmes and Structures. STEPS management has through various participating initiatives identified several strategic guidelines to shape the practical initiatives in general, and corresponding criteria for an 'ideal' curriculum environment.

Included within STEPS initiatives is the introduction of several new development-oriented, output- driven qualifications. Among them is the new qualification: Higher Certificate: Renewable Energy Technologies. This Certificate is aimed primarily, but not exclusively, at people in the usual feeder area of the Central University of Technology who are employed or plan to be employed with various installation and maintenance providers for renewable sourcing of electricity to the homestead, farmstead and even smaller businesses.[1]

2 ENERGY IN SOUTH AFRICA

Eskom is involved in practically every area of electricity sector, from generation, transmission and retail. In 2012 Eskom had a generating capacity of 44 145 MW, municipalities pro-

duced 2400 MW, and private companies provided 800 MW. Renewable energy in 2012 only produced in the region of 1% of the electricity. [2]

South Africa relies heavily on its Cole resources for electricity generation. In 2010 because of economic growth and an increase in on grid demand, the electricity reserve margin fell to below 10%. This led to load shedding and cased many interruptions in the electricity supply [3].

Renewables already play a major role in the energy mix in many countries around the world. In 2012, prices for renewable energy technologies, primarily wind and solar, continued to fall, making renewables increasingly mainstream and competitive with conventional energy sources [3]. A target of 10 GWh from renewable energy sources by 2013 was set in the 2003 Government White Paper on Renewable Energy[5]. South Africa has identified renewable energy as a key element to satisfy its future energy needs. This strategy crystallizes in the country's second Integrated Resource Plan, which was published in 2010 and laid out a roadmap for the upcoming 20 years [4]. Table 2.1 shows ESKOM generation capacity in 2014 as well as the Department of energy's estimated generation capacity per technology according to the 2013 updated integrated resource plan of 2010 (IRP2010).

Table 2.1 ESKOM's generation capacity in 2014 as well as the Department of energy's estimated generation capacity per technology according to the 2013 updated integrated resource plan of 2010 (IRP2010)

Technology option	Maximum capacity 2014	IRP2010 updated in 2014 for 2030
Coal-fired	37 667 MW	36 230 MW
New Coal		2 450 MW
Combined-cycle gas-turbine project (CCGT)	1 207 MW	3 550 MW
OCGT / Gas Engines		7 680 MW
Hydro Imports		3 000 MW
Hydroelectric	600 MW	690 MW
Pumped storage	1 400 MW	2 900 MW
Nuclear	1 800 MW	6 660 MW
Wind energy	3.2 MW	4 360 MW
Other		640 MW
Photovoltaic (PV)		9 770 MW
Concentrated solar power (CSP)		3 300 MW
Distribution Embedded	62 MW	
Total	**44 175 MW**	**81 230 MW**

In November 2013, the first solar farm of 75MW near Kalkbult was connected to the national grid. Kalkbult was the first of many to follow. The Renewable Energy Independent Producers Procurement Programme, directed by the Department of Energy, has so far approved 31 projects for the Northern Cape.[6] As can be seen in figure 2.1 many of the preferred bidder PV projects, under bidding window 1 and 2, fall within the Northern Cape and Free State.

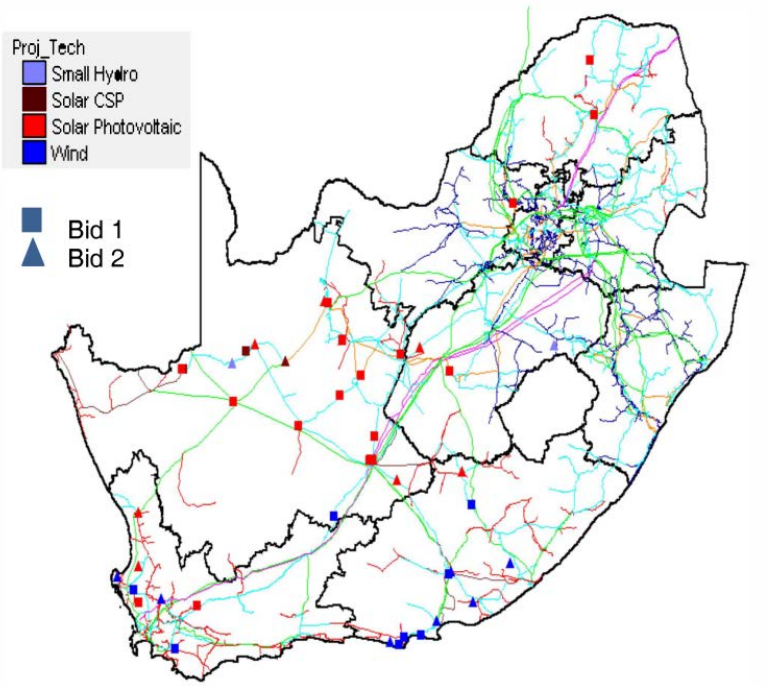


Figure 2.1 Renewable energy preferred bidders in window 1 and 2 of the bidding process [5].

This aria is also the main source of students for the Central University of Technology, Free State (CUT). Given the commitments by the South African government and the need for technical capacity in the renewable field, a Higher Certificate course in Renewable Energy Technologies (HCRET) were developed.

3 CONSIDERATIONS AND CHALLENGES IN THE DEVELOPMENT OF THE HIGHER CERTIFICATE IN RENEWABLE ENERGY TECHNOLOGIES (HCRET)

3.1 Process timeline

The first submission to Department of Highter Education and Training (DHET) for the Higher Certificate course in Renewable Energy Technologies (HCRET) was done in September 2011 with a second submission in May 2012. It was submitted for approval to Council on Higher Education (CHE) in Desember 2012. The Council on Higher Education (CHE) approved the application and it was forwarded to South African Qualifications

Authority (SAQA) for registration onto the qualification framework. The aplication was open for public commend till September 2013 and The CUT receaved South African Qualifications Authority (SAQA) registration in October 2013.
The first intake were in January 2014 with 30 students from whitch 25 were sponsored by the Energy Sector Education and Training Authority (ESETA).

3.2 Staff deployment

Department of Electrical, Electronic and Computer Engineering have the services of 18 full time staff members with extensive experience in both the academic and the industrial environments. Lecturing staff attended various courses in renewable energy. One staff member was send to Germany to attend a three-week course in solar, wind and biomass technologies.

3.3 Facilities

A new renewable energy laboratory were developed in the existing engineering buildings. De Lorenzo experimental training units were installed for use in experiments for the subjects solar and wind. Currently ten 300W solar modules, and one 1.2 KW wind turbine are being installed on the roof of the renewable laboratory. This installation will take the laboratory of grid and also serve as demonstration units for solar, and wind technologies.

3.4 Library and Information Centre (LIC).

Lecturers have access to network search facilities from their office computers and computers are available in the library for use by students that need access. Audio-visual material for educational purposes are available and lecturers continuously identify new media to purchase.

A well-established interlibrary loan service is provided. Any book, journal or article in a journal can be obtained within a relatively short period. A full-time librarian per faculty is available to support students with advanced searches for information.

There are 210 computers available in the Library and Information Centre (LIC). These computers are equipped with internet access, MS Office programmes and a research toolbox. Adequate study stations are available in all sections of the LIC. Two 24-hour study rooms are also available to students. Orientation workshops for students, on how to access information, take place on a regular basis.

3.5 Admission requirements for HCRET

For candidates who matriculated in 2007 or before the admition requirements is a Senior Certificate with a minimum score of 27 on the Central University of Technology, Free State (CUT) scoring scale, plus a minimum of 50% on Standard Grade or 40% on Higher Grade in both, Mathematics and Physical Science. For candidates who completed the NSC in 2008 and thereafter the admission requirements is a Senior Certificate with a minimum score of 27 on

the Central University of Technology, Free State (CUT) scoring scale, plus a minimum mark of 50% (level 4) in both Mathematics and Physical Science.

3.6 Compulsory Subjects for Higher Certificate in Renewable Energy Technologies (HCRET)

The time span for the Higher Certificate course in Renewable Energy Technologies (HCRET) is one year. The year is divided in two semesters, with six subjects per semester. The subjects Digital Literacy and Academic Literacy is compulsory for all the courses offered at The Central University of Technology, Free State (CUT). The subjects Mathematics I A and Mathematics I B are serviced by the Department of Mathematical and Physical Sciences, and the subject Health and Safety: Principles and Practice are serviced by Professional service Provider from within this field.

The following subjects are offered in the first semester.

- Digital Literacy
- Academic Literacy and Communication Studies
- Mathematics I A
- Electrical Engineering I
- Applied Physics of Energy Conversion
- Solar Energy Systems I

The second semester's subjects are as follow:

- Health and Safety: Principles and Practice
- Electrical Installation Practice
- Power Generation and Storage
- Solar Energy Systems II
- Small Wind Generation
- Mathematics I B

3.7 Outcomes

Fundamental and Core learning that was incorporated within the Higher Certificate in Renewable Energy Technologies (HCRET) include but is not limited to the following:

1. Explanation of the physics of energy conversion into electricity.

2. Explanation of the basic economics and finance of sustainable electricity practices.

3. How to perform basic calculations relevant to quantities and costs related to the installation of renewable energy conversion equipment and the storage and distribution of converted electricity.

4. Perform basic calculations related to physics in the conversion of energy into electricity.

5. Explanation of the basic common and different features of a variety of electricity power plant systems and operations in relation to a national / regional / macro grid.

6. Explanation of the basic managerial principles.

7. Installation of simple plumbing and electrical connections.

8. Explanation of the basic principles of the installation of electrical connections.

9. Explanation of the need in real construction, installation and maintenance to co-operate with other trades (e.g. plumbing).

10. Explanation of the principles in the storage of wind, solar and biogas converted electricity

11. Explanation of the health and safety principles.

12 Execute basic health and safety drills.

Achievement of the Higher Certificate in Renewable Energy Technologies (HCRET) is a way for candidates to demonstrate that they have achieved a basic knowledge of the fundamental principles of the application, design, installation and operation of PV, Solar and Small Wind energy systems.

4 CONCLUSION

The first intake for the Higher Certificate course in Renewable Energy Technologies (HCRET) were in January 2014. Currently there is an overwelming interest from indusrty, not only in this cource but also in accredited short courses relating to this qualification.

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Pierre E Hertzog received his DTech: Electrical: Engineering degree in 2004 from the Central University of Technology. His research interests include alternative energy and automation & manufacturing systems.

Herman J Vermaak received his PhD in 2005, he is the HOD of the Electrical, Electronics and Computer Engineering Department at the Central University of Technology. His research interests are reconfigurable assembly and manufacturing systems and renewable energy technologies.

Johan H Raath received his MTech: Electrical: Engineering degree in 1996 from the Central University of Technology. His research interests include alternative energy and power conversion systems.

DEVELOPMENT OF A ROTOR FROM POWDER METALLURGY AND PERMANENT MAGNETS FOR A SYNCHRONOUS MACHINE USED IN WIND TURBINES

Monir Göethel Borba[1] – monir.borba@ufrgs.br

André Carvalho Tavares[1] – andre.tavares@ufrgs.br

Diego Pacheco Wermuth[1] – diego.wermuth@ufrgs.br

Moisés de Matos Dias[2] - moisesmd@ig.com.br

Lírio Schaeffer[1] - schaefer@ufrgs.br

[1] Metal Forming Laboratory. Metallurgic Engineer Department. Federal University of Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.

[2] Feevale University, Novo Hamburgo, Rio Grande do Sul, Brazil.

Abstract

This paper aims the development (design and construction) of a rotor that to be assembled in a three-phase synchronous electric machine with permanent magnets for application in wind turbines. The need for equipment that consume fewer raw materials during the manufacturing process and having better performance are the reasons guiding this research. Actually the core of a rotor is made using low carbon steel plates or laminated iron silicon. This work will replace this traditional materials for a pure iron sintered core obtained from powder metallurgy. The powder metallurgy is a new way to obtain parts with a minimum waste. The electrical machine was redesigned for obtain better results during application. The magnets used for the rotor was made from an alloy of neodymium, iron and boron, called rare-earth magnet. This magnet was choose because are the strongest type of permanent magnet commercially available.

Keywords: rotor core; powder metallurgy; renewable energies; wind turbine.

1. Introduction

Electric power is the most demanded form of energy in the world today. Millions of people are consuming more and more this energy, which is of fundamental importance for the development of modern societies. Due to its great versatility, it can be converted to various forms of use: generation of light, power to move engines and various electrical and electronic products such as computer, refrigerator, microwave, shower, television and among other numerous uses. Several aspects have contributed to the increase of global electricity consumption, among them are the continuous growth of the world population, progressive creation of programs of access to electricity, accelerated urbanization and the rapid economic development in emerging countries, especially China and India. [1, 2]

Since the dawn of humanity, the man has been developing skills that helped him to develop objects with the purpose of facilitating your everyday life, like the invention of the wheel in prehistory, the steam engine during the industrial revolution in the early modern period and with the electrical energy in the contemporary age, among many others. The electricity brought technological advances that are of extreme importance to modern society. Equipment such as computer, television, stereos, air-conditioners, heaters, tablets, smartphones and many others exist only thanks to electricity. All these new technologies require ever more power and thus arises a preoccupation with electricity-generating sources. Currently the world is dependent on non-renewable energy sources such as oil, natural gas and coal. This is a problem, since they are not renewable resources along the human time scale, since its formation occurs through a process that takes thousands of years. The forecast is that in a few years these energy sources run out, requiring that other sources are used. [3, 4]

Faced with the terrible prediction regarding non-renewable sources, renewable sources are increasingly highlighted. Many countries have developed a strategic planning to seek self-sufficiency in power generation combined with the diversification of the energy matrix, in order to obtain a greater security of energy supply due to the variation in prices of inputs or climatic adversities. The use of wind energy for electricity production gained great importance from the decades of 80 and 90, where the wind-electric utilization has reached a scale of most significant contribution to the electric system, in terms of generation and economy. The technological development of wind turbines has become driven by the industries in the sector that were born, fed by incentive programs. In Brazil the government was created a program to encourage alternative sources of electric power called Programa de Incentivo às Fontes Alternativas de Energia Elétrica (PROINFA) in 2004, with the objective of increasing the participation of the electric energy produced by renewable sources in the national interconnected electrical system and develop the nationalization of production technology of wind turbines. [5, 6, 7]

In the search for development of new materials and technologies for wind turbines, a manufacturing process has excelled in this regard. The powder metallurgy is a manufacturing process that produces parts from metal powder. This process consists in compressing the metallic powder with a certain pressure in a die with the format as close as possible to the desired and take this piece for the sintering stage, aiming to provide mechanical strength. Has great application in the automotive industry and has gained great prominence in the area of renewable energy due to its use in the production of rare-earth magnets used in wind turbines. [8]

Besides the production of magnets, the powder metallurgy has been featured in another field of renewable energy. It has gained importance in the productive process of electrical machines used for power generation in wind turbines. Currently the stator and rotor cores of electrical machines are built with low-carbon steel sheets. Some higher-yielding machines still built with steel-silicon plates. The overall process for the manufacture of these cores basically consists of lamination, cutting, treatment for insulation, packaging and packing. The request for lower costs of production is a decisive factor to make wind energy affordable around the world. The powder metallurgy

reduces production costs, since it is capable of producing parts with geometry next the desired, requiring few subsequent adjustments. Due to the characteristics of sintered materials, it will be possible to obtain lighter machines with larger incomes, resulting in significant energy savings in the production process.

In demand by expanding the use of powder metallurgy in renewable energy evaluated the process of construction of the core of a three phase synchronous machine rotor with permanent magnets for use in wind turbines. The process of construction of the rotor core comprises the steps of design of the new rotor, compacting, sintering, development of rare-earth magnets and the union of components. The ultimate goal of this research is to obtain a sintered rotor with the same dimensions and characteristics of a rotor built in the traditional way, so it can be tested with different configurations of stators in the laboratory of renewable energy development group (GDER) at the Federal University of Rio Grande do Sul (UFRGS).

2. Materials and methods

1.1. Rotor core design

The rotor core developed in this work was based on a rotor used in a three-phase induction motor with high performance, with the specifications listed in table I.

Table I – electrical machine specifications

Manufacturer	Voges
Power	7.5 KW
Model	VTOP 132S
Tension	220 V
Frequency	60 Hz
Number of poles	4
Nominal rotation	1760 rpm

This machine has the rotor core consisting of laminated steel sheets, which will be replaced by a block, composed of five pieces of material composed of sintered pure iron. The topology and the rotor core dimensions were based on existing dimensions that accompanies the rotor motor. The core design also took into account the packing process involved in powder metallurgy, once the rotor has relatively large dimensions, an array for compression should also be developed. Figure 1 presents the array that was designed for compacting.



Figure 1 – Compressing die

2.2. Raw material

The choice of metallic powder to be used is the first step for the success of the application of a sintered material. The main raw material used in powder metallurgy are iron-based alloys, which depending on the composition, giving the pieces produced different chemical and physical properties, such as density, porosity, permeability, hardness, surface finish, noise reduction and others. For the construction of the rotor core developed in this research, we used the pure iron powder, model ASC 100.29, manufactured by Höganäs Brazil. The figure 2 presents the image of a particle of powder. This material was chosen for being soft magnetic, this is, having the ability to amplify a thousand times an externally applied magnetic field. This property is what makes the existence of most electric machines: motors, generators and transformers. Because of its high degree of purity, the ASC 100.29 iron powder has high compressibility, and can be compressed into a single process and reaching densities of up to 7.2 g/cm³. [9]

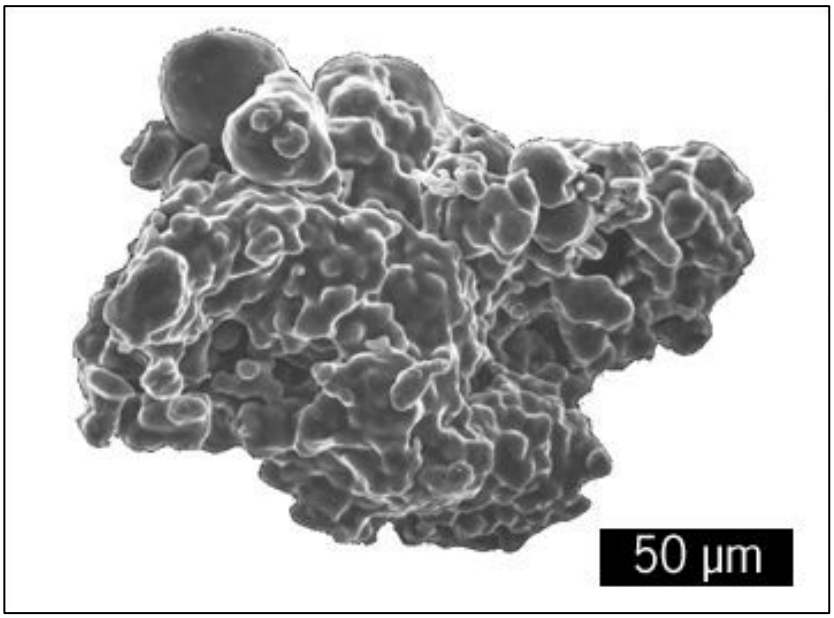


Figure 2 – Iron powder particle ASC 100.29

2.3. Mixing and compaction

To the iron powder was added a lubricant material, which has as main function to reduce the friction between the components of metallic powder and the compression die and friction between powder particles during the compression process. The most commonly used types of lubricants are: zinc or lithium stearate, natural waxes and synthetic lubricants. The lubricant used in this research was the zinc stearate, which presents as main advantages: assist the increased density of the mixture, good compressibility, good performance in lubrication and extraction of compacted, low cost, among others. As disadvantages, can cause stains on the surfaces of the parts, generate significant quantities of waste material inside the furnace by its melting point be 120ºC and introduce restrictions of use by contain zinc in its composition. The quantity of lubricant added to the powder to the mixture was 2% by weight of the metallic powder. The two elements were mixed with the aid of a V type mixer, shown in figure 3, available in the laboratory of Metal Forming Laboratory (LdTM) at the Federal University of Rio Grande do Sul (UFRGS). The time of mixture between the two materials was approximately fifteen minutes, so that a homogeneous mixture between the two components.



Figure 3 – V type mixer

After mixing the powder and the lubricant, starts the powder compression step. This process aims to give the desired geometry. This step must be well planned and executed with care, since a badly executed compression may lead to a wide variation of density, compromising the performance of the end product. Furthermore, the making of tooling requires planning and care, because when there is a need for a higher density of the piece must be used high pressures of compressions.

For obtaining the parts that make up the core of the rotor was used the compression process called double action with floating die. In this process the lower puncture does not move, occurring just a relative movement between the tooling. This process was chosen because of the centralization of the neutral line of the piece avoiding the density variation. The compression was performed with a hydraulic press model PH600, brand FKL, ready to use at LdTM of UFRGS. This press, shown in figure 4, is able to applying a force of 600 tons while compacting.



Figure 4 – Hydraulic press PH600

The die used in compression has a simple geometry, for obtaining parts in cylindrical format, with a diameter of 150 mm. The figure 5 presents the die mounted on the hydraulic press and figure 6 shows the die's cavity being filled with the mixture of metallic powder and lubricant.



Figure 5 – Die mounted on the press



Figure 6 – Die being filled with powder

The compression process resulted in six pieces in cylindrical format, shown in Figure 7. Table II presents the weight and dimensions of the pieces obtained.

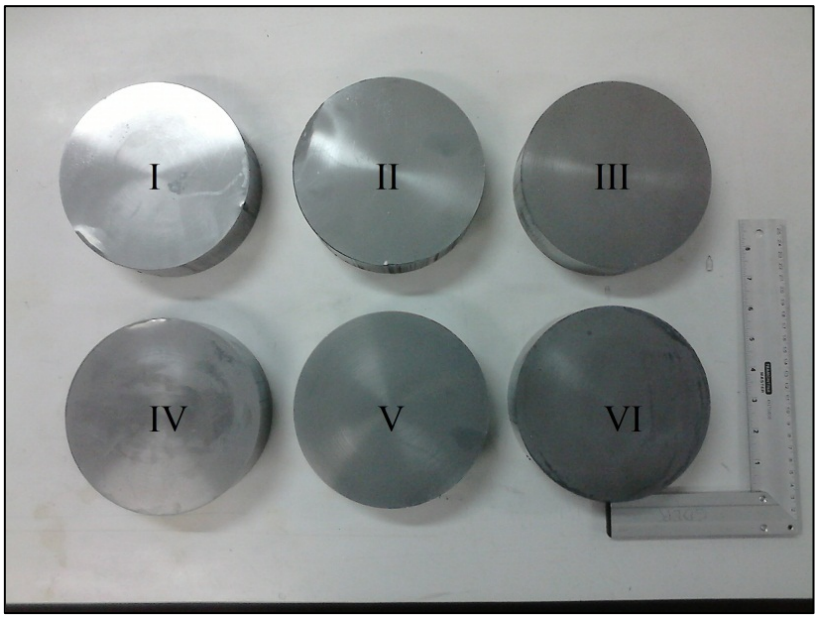


Figure 7 – Pieces obtained after compaction

Table II – compressed parts Information

Part number	Weight (Kg)	Height (mm)	Diameter (mm)
I	5.90	51.55	150
II	5.87	52.12	150
III	5.94	51.45	150
IV	5.91	50.76	150
V	5.95	52.28	150
VI	5.89	52.25	150

2.4. Sintering

Sintering is the process by which the compressed powder (or not) is transformed into a solid, due to the atomic diffusion transport mechanisms. Sintering occurs at a temperature below the melting point of the main material, usually in the order of 2/3 to 3/4 of this point. During sintering exists the reduction of system free energy by decreasing the specific surface of the material, resulting in the formation of the grain contours and neck growth between the particles. [9]

Due to the large size of the pieces, these were sent to a company that specializes in sintering. To carry out this step was used a continuous-type furnace, because this presents great load capacity. Continuous furnace have four distinct zones: preheating, sintering, slow cooling and final cooling. The preheating zone function is gradually warming the pieces that are being introduced into the furnace and remove the lubricant that was used in parts compression. Was used a heating rate of 10° C/min up to a temperature of 500° C, where the pieces remained for 30 minutes. In the sintering zone is where the process of forming connections between compressed powder particles occurs. The pieces were heated 1.150° C and remained in the area for 60 minutes. Finalized this time, the pieces follows the slow cooling zone, where occurs the transition of temperatures, in order to avoid tensions in the material obtained from the thermal shock and ensure a better development of the microstructure. Finally the final cooling zone plays the piece below the cooling point, with controlled atmosphere, avoiding contact with external air environment. [9]

The sintering atmosphere is a very important requirement for the success of the process, because it should not be held in the presence of oxygen. In order to prevent the infiltration of air

through any opening in the furnace, is applied an atmosphere that must be maintained at a pressure higher than atmospheric pressure. This control can be accomplished by adjusting the gas flow. The sintering atmosphere has other functions, in addition to prevent the entry of oxygen into the furnace. It helps to extract the lubricant and other organic composite that has been added to powder mixing, helps in uniformity of heat transfer through conduction and convection, minimizes unwanted chemical reactions in sintered parts, reduces the surface oxide layer and prevents formation of new oxides during sintering and can be used to change the alloy composition compressed by removing or adding elements such as carbon and nitrogen. For this research it was used an atmosphere composed of 5% hydrogen and 95% of nitrogen, also known as green gas. Figure 8 shows the final result after the sintering process. The pieces presented a surface darkening due to a superficial oxidation, which was removed later in the process of machining and assembly of the rotor. [9, 10]



Figure 8 – Piece after the sintering process

2.5. Magnets

So that the rotor of an electrical machine can work it must be produced an electromagnetic field around them. The most traditional form of rotor construction uses copper conductors for the generation of the magnetic field, thus forming an electromagnet in the rotor. This process requires physical contact commonly called "brushes" for the transmission of electric energy of the fixed part to the rotating part and an external source of excitement power for producing currents will circulate by windings of the rotor. These currents which cause Joule's losses in the rotor field , decreasing the efficiency of the machine. With the development of knowledge in electrical machines and electromagnetism, were possible make changes on the engine rotors constructively, in order to obtain better yields. An example of this development is the replacement of the copper conductors for high energy permanent magnets. The magnets more employees for this use are magnets made from rare earths mainly the neodymium iron boron. The popularization of the use of permanent magnets in electric machines has occurred thanks to the growth of wind energy as a synchronous generator has the same form of functioning of a wind turbine with synchronous permanent magnets. The wind generators built from electrical machines with permanent magnets present as low maintenance advantages, because there was no need for external power supply or brushes for its operation. This fact also contributes to increased yield of the wind turbine and improves and torque/volume ratio. [11, 12]

For the development of this work were used magnets of neodymium iron boron, covered by a coating of nickel, which ensured excellent magnetic feature. The magnets were manufactured with a specially developed geometry to better adapt to rotor cores designed. The thickness of the magnets was calculated from an equation that took into account the values of rotor diameters traditionally produced and the cavity of the die, resulting in approximately 6.55 mm. The value of the length of the magnets was defined as being half of the total length of the new rotor, which resulted in a length of 95 mm for each magnet. The magnetization of the magnets was defined in terms of the creation of the rotor poles. Some parts of the magnets were driven magnetically with the north pole at the top and south pole at the bottom, and others with south at the top and the north at the bottom. Figure 9 presents the magnet used.



Figure 9 – Magnets of neodymium iron boron

2.6. Assembly

The assembly of parts produced by powder metallurgy in the new rotor shaft required a machining process. Five pieces produced were used for the assembly process. First, was performed a facing on the surfaces of the parts to remove imperfections and surface oxidation with the objective of obtaining the perfect contact between the surfaces of the parts in the process of union. The next step was composed by an internal turning, with the goal of opening a hole for fitting of parts in the rotor shaft with a tolerance of approximately 1 mm interference type, where the pieces were fitted under pressure, in order to avoid that they have some movement during operation. After the fitting of the five pieces on the shaft, turning was held outside of the set, to suit the diameter of the new rotor core parts to the produced commercially.

Completed the rotor turning, it was possible to pass to the stage of milling, which aimed to produce four undercuts. These undercuts were defined with height equal to half the height of the magnets, because entering the magnet up to half of its height, the entire flow produced by the magnet pole will for the rotor core and will not be dispersed by the magnet. Furthermore, the undercuts serve to facilitate the fitting of the magnets in the rotor. The figure 10 shows the project parts machining of the rotor and figure 11 shows a piece that was machined to show the individual result of milling.

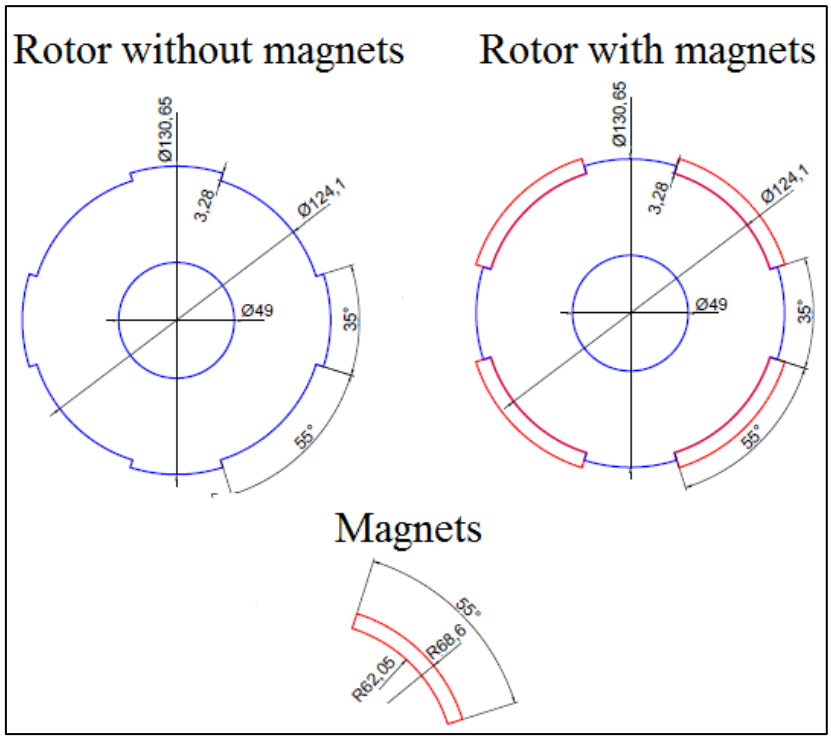


Figure 10 – Project of parts machining

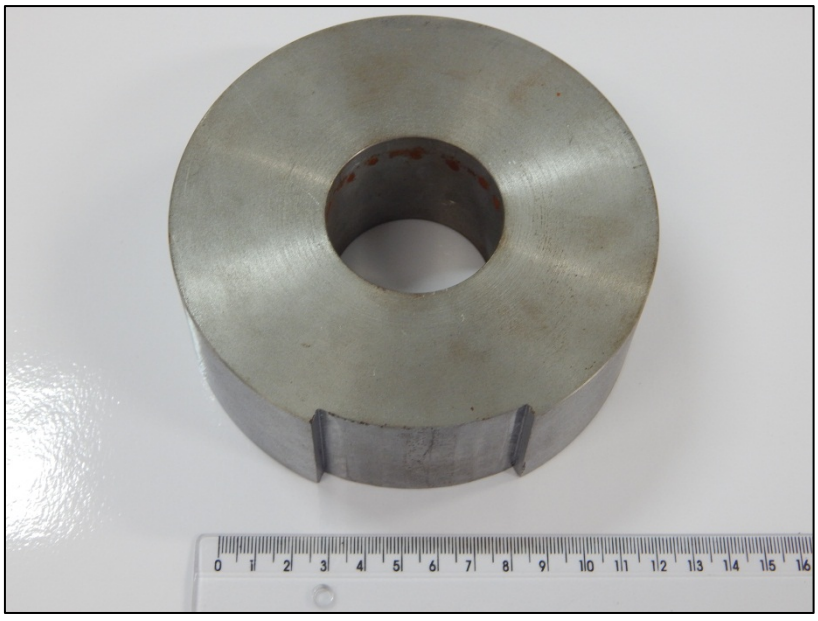


Figure 11 – Piece with undercut for fitting the magnets

The fixation of the rotor magnets was accomplished with glue consisting of a resin (epoxy) and hardener (polyaminoamides), which features total 24 hours drying after applying. The fixing magnets became necessary to prevent moving during use of the rotor and to keep them close to one another, by reason of the pairs of bonded magnets repel each other over the direction of magnetization that each contains. The result of the glue magnets on the rotor is shown in figure 12.



Figure 12 – Rotor with magnets

3. Conclusion

The depletion of non-renewable energy sources is an issue that is generating global apprehension. The great dependence of oil derivatives, which currently can't keep up with the growth of your demand, has motivated the search for sustainable development of renewable energy sources that result in minimal impact to the environment. A sign of concern about the shortage of oil is the fact that large oil companies are investing in renewable energy sources. In addition, large portions of the world's oil reserves are located in regions that have ethnic character or political conflicts that are difficult to solve in a short time. Another problem caused by the energy sources used to actually is the increased concentration of carbon dioxide (CO_2) in the Earth's atmosphere. This increase has contributed to global warming and all the problems arising from increasing the planet temperature. There is a growing global debate around this subject, due to the fact that the concentration of CO_2 have increased because of the wide use of fossil fuels.

In virtue of this future perspective, renewable energy sources have been collaborating for the diversification of the energy matrix of many countries. In Brazil, the program to encourage alternative sources of electric power (PROINFA) contributed to the expansion of wind power and promoted the incentive the nationalization of the technology. The research for a production process bring environmental advantages is very important when seeking a sustainable energy. The powder metallurgy emerges as an alternative to development as it has as a characteristic little waste of raw materials and low power consumption. Aimed at the popularization of wind energy and decrease its cost, the powder metallurgy arises as an alternative to the production of parts that make up the wind turbines.

In order to assess the feasibility of using powder metallurgy in the production of components for wind turbines, the core development of the rotor for a synchronous three-phase machine with magnets of neodymium-iron-boron was realized. The mixture of pure iron powder with solid lubricant was the raw material chosen for the composition of the pieces. With a die elaborated for the accomplishment of this work, were compressed six cylindrical pieces. These parts have

undergone a sintering process, which aims to confer solidity compressed parts. During this process the pieces had their high temperature near the melting point, occurring as soon as the connection between the particles of the material. The powder metallurgy is a manufacturing process "near net shape", that is capable of producing parts close to the final dimensions, but often a later operation process is necessary. Machining performed on parts was necessary because of minor dimensional adjustments is necessary in height and in diameter. Was also performed a hole in each piece, for inserting the rotor shaft, and four undercuts for the magnets. The use of magnets of neodymium iron boron has great importance for electric machines, modernizing its constructive aspect and improving its performance.

The final evaluation of a rotor core production by powder metallurgy was very positive. Get the rotor in a simple way, without major difficulties, only making minor adjustments in the course of proceedings. With the sintered pure iron rotor, it is possible to perform a new search step, comprising performance testing of rotor with different stators constructive forms. It is concluded that the powder metallurgy fulfills its role of being a sustainable manufacturing process and which can have great success in the area of renewable energies.

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Author's biography

Monir Göethel Borba – Master student at Metallurgical and Materials Engineering from Federal University of Rio Grande do Sul in Renewable Energies Development Group, working with materials for renewable energy. He is graduated in Control and Automation Engineering at Pontifical Catholic University of Rio Grande do Sul. The main areas that he studies are wind turbines, powder metallurgy and renewable energies. He is member of the organizing committee of the 4th International Conference on Materials and Processes for Renewable Energy.

André Carvalho Tavares – M.Sc. in Mining, Metallurgical and Materials Engineering, by Federal University of Rio Grande do Sul. He is graduated in Technology in Mechanical Manufacture by the Federal Institute of Education, Science and Technology of Rio Grande do Sul. D.Sc. student at Post-Graduation Program in Mining, Metallurgical and Materials Engineering, working at the Laboratory of Mechanical Manufacture (LDTM / UFRGS) in the project developing biodegradable stents, obtained by injection molding powders whose orientation is Doctor Professor Lily Schaeffer and co-supervision of Prof. D.Sc. Diego Mantovani of Université Laval – Canada.

Diego Pacheco Wermuth – Master student at Metallurgical and Materials Engineering from Federal University of Rio Grande do Sul, working with Powder Metallurgy and Metal Injection Molding. He is graduated in Manufacturing Mechanical Technology by Federal Institute of Rio Grande do Sul. Has published 17 articles in the areas of Powder Metallurgy, Metal Injection Molding and Machining. He is member of the organizing committee of the International Powder Metallurgy Conference – Brazil – RS.

Moisés de Mattos Dias – Electrical Engineering, M.Sc. and D.Sc. in Mining engineering, metallurgical and materials at Federal University of Rio Grande do Sul. Has experience in the area of Materials and metallurgical engineering, with emphasis on powder metallurgy, mainly in the following areas: electronic equipment, instrumentation, powder metallurgy, magnetic materials and sintered magnetic cores.

Lírio Schaeffer – Mechanical Engineer, D.Sc. in Mechanical Forming - Rheinisch-Technische Hochschule Westfälischen, Aachen - Germany. Since 1976 is Professor at the Federal University of Rio Grande do Sul - Department of Metallurgy and coordinator of Laboratory of Mechanical Manufacturing (LDTM), working mainly in the following areas: forging, stamping, powder metallurgy, biomedical materials. Have experiences in alternative energies. Currently is ad hoc consultant of the Foundation for Research Support of the State of Rio Grande do Sul (FAPERGS), Coordination for the Improvement of Higher Education Personnel (CAPES), consultant to the National Council for Scientific and Technological Development (CNPq) and Consultant Foundation for Research Support of the State of Rio de Janeiro (FAPERJ).

DEVELOPMENT OF SYNCHRONOUS GENERATOR WITH HARD DRIVES COMPONENTS

Ramos, Felipe. [1a]
Borba, Monir.[1b]
Wermuth, Diego.[1c]
Tavares, André[1d]
Schaeffer, Lirio. [1e]
Canalli, Vicente. [2]

[1] *UFRGS, Department of Mines, Metallurgy and Materials Engineering, Porto Alegre – RS, Brazil, a)felipe.guimaraes@ufrgs.br; b)monir.borba@ufrgs.br; c)diego.wermuth@ufrgs.br; d)andre.tavares@ufrgs.br e)lirio.schaeffer@ufrgs.br*
[2] *PUCRS, Departament of Electric Engineering, Porto Alegre – RS, Brazil, a)vicente.canalli@pucrs.br*

Abstract

This paper aims the study and development of a low cost synchronous generator prototype. The prototype was building with damaged hard disk drives and will be an axial flow synchronous machine with permanent neodymium – iron – borum magnets. A analyze of the magnet was done, observing the stator magnetic flow and wave forms. A CAD software and conventional scanner were used to position the magnets at the rotor disk. After done the prototype, tests were done and the wave forms were analyzed using an oscilloscope. The development of this generator will be done following the green idea that how important are build new things using an existent materials instead of remove materials from nature. The parts used were funded at electronic garbage available at the university. This generator could be used in a small wind turbine, generating electricity with a renewable source.

Key words*: synchronous generator, neodymium iron boro magnets, hard disk drives.*

1. INTRODUCTION

The study and construction made in this paper will be grounded in work involving the build of small wind generator. The prototype is a permanent-magnet synchronous machine with axial flow found in forums of do it yourself (diy) [1].

Recycled parts will be used, to use parts usually discarded in trash. The purpose of this work is the construction and study of a prototype could be use in low cost small wind generator, the use of recycled parts found in hard disk. The study will aim to examine how to nominal-/actual- wave induced voltage in the windings, and synchronous reactance and maximum rated output of this generator, which will be ac.

2. MATERIALS AND METHODS

2.1. Máquinas elétricas de fluxo magnético axial com imãs permanentes

The axial flow machine has its first documented record of the date 1831. In 1837, it was invented the radi al flow machine, which has been used almost exclusively, since its creation.[2]

With high volumetric efficiency of rare-earth permanent magnetic materials and their costs more affordable enabled the exploration of electric machines of different configurations. The

magnetic excitation classically performed by current densities, obtained a reduction in size and further the yield is favored by the use of rare-earth magnetic materials.[3]

With the development of permanent magnets with higher magnetic flux, there was an increase in competitiveness between the different electric machines types, making it attractive to use axial flow machines for some applications; in the current technological context has considerable potential in low speed applications, for example, wind generators. [2][3]

The axial flow electric machines may present the following construction structures: [2]

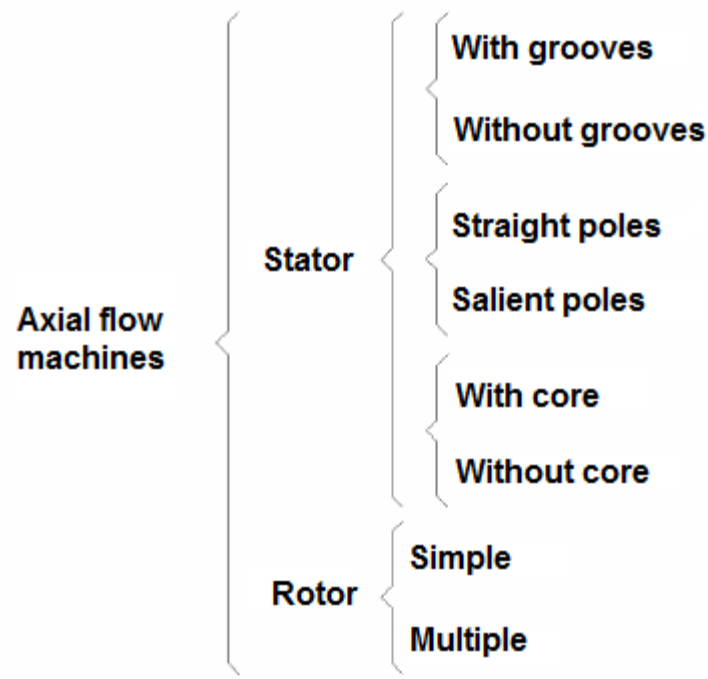


Figure 1- Constructive ways of axial flow machines

The prototype that was built is an axial flow machine with stator without core and multiple rotors, in this case, two rotors. In the absence of core the machine is known as coreless.

Comparing the coreless machine with other machines axial flow, the coreless features simple assembly, and an estimated average cost of manufacturing.[4]

2.2. Hard magnetic materials

Between hard magnetic materials we can distinguish two types "magnets classic" and "modern". The first group consists of alloys with a low energy density caused by the effects of the precipitated anisotropy. The second group is characterized by magnets with considerably higher energy density, and these are based on the inter-metallic compounds of transition metal / rare-earth, which provide a high magneto-crystalline anisotropy.[5]

Through the process of powder metallurgy is obtained magnetic orientation of the particles constituting the worked material (anisotropic magnets), obtaining magnetic properties well above those obtained by conventional metallurgical processes such as casting. Added to this that powder with different chemical natures is easy to obtain, it is enough to mix the powders homogeneously.[6]

The main magnets marketed today are ceramic (ferrite), AlNiCo alloys and rare earths, such as samarium cobalt and neodymium-iron-boron. With the exception of cast AlNiCo, are all obtained through the processes of powder metallurgy. Thus, the today magnets marketed comprise four major groups, with the sintered ferrite magnets comprise the largest group. The magnets AlNiCo make up 9.23% of magnets world production and can be obtained by sintering or casting. The third group is

composed of laminated magnets as FeCoCr, among others. The latest group belongs to the rare-earth magnets such as samarium-cobalt (Sm-Co) and neodymium-iron-boron (Nd-Fe-B), also sintered, corresponding to 23.76%, and are the most powerful magnets currently produced. In these four groups, the most important materials are those obtained by sintering. [7]

The four basic processes of powder metallurgy are: Obtaining powders, mixing of the powders, compaction and sintering or curing. Sometimes we need a fifth stage as grinding. In powder metallurgy, the powders, after being mixed, they are compacted in dies where they take the shape of the die cavity. After, they are placed in furnaces for sintering, where they acquire consistency and strength.[8]

Neodymium magnets were first introduced in 1982 simultaneously by Sumitomo Specialty Metals (Japan) and General Motors (USA) and finally marketed from 1986. These magnets are used extensively in renewable energy (wind turbines), automobile (engines, brake systems, stereo speakers), electronics (sensors, hard drives of computers) industry. [9]

The values of the energy product and coercivity of NdFeB magnets are the highest of all magnetic materials, and the remaining induction has a relatively high value. The catch of this material lies in the thermal characteristics, the normal operating temperature is less than the working temperatures of some machines, is around 150 º C, and the temperature of Curi is also low, between 300-320 ^{0} C. [10]

The project works on some machines greater than 150 º C temperatures, but in axial flow machines, when given due importance for cooling, you can work at lower temperatures.

2.3. Reused parts of the hard drive

Tht Figure 2 help to illustrate the basic structure of a hard disk:

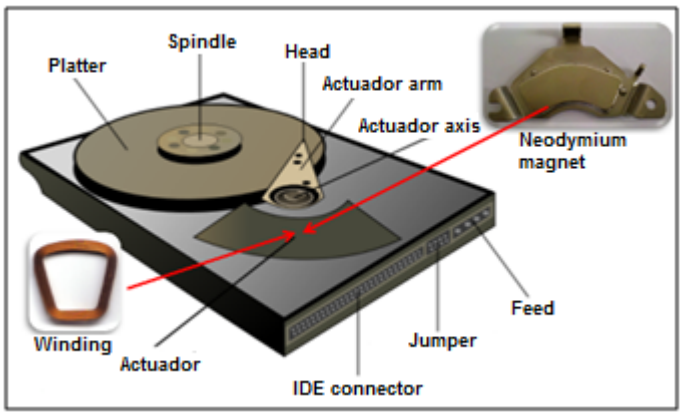


Figure 2 - Part of hard drive and neodymium magnet location

The parties used a hard drive in the project are [11][12]:

a) Platter e Spindle: The plates are disks where data is stored. They are made typically of aluminum (or a crystal type) covered by a magnetic material and a layer of protective material.

b) Actuador: also called a voice coil, the actuator is responsible for moving the arm above the surface of the plates and thus allow the heads to do their job. For the movement occurs, the actuator contains a coil on its end, different from that used to record the data disk. The same is traversed by a current that interacts with the magnets. These magnets are neodymium iron boron.

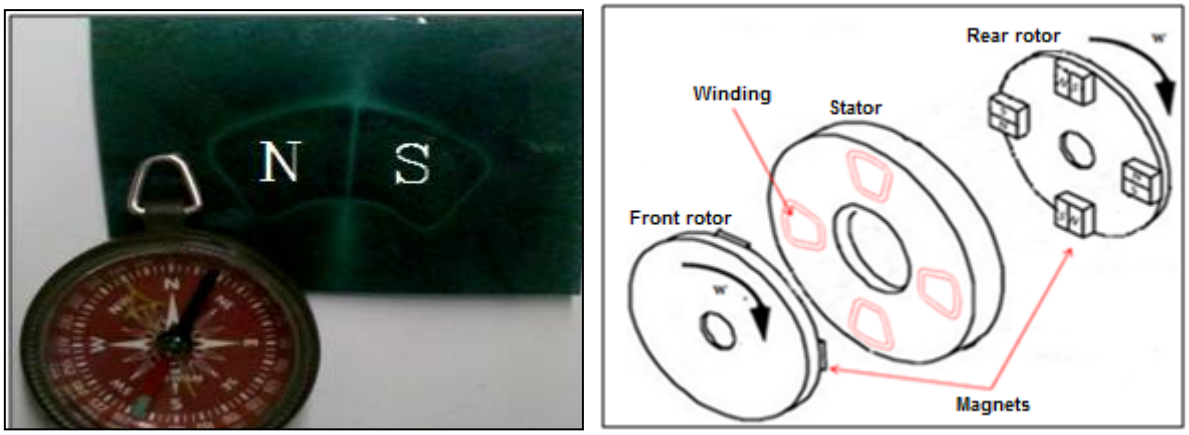
Usually a hard drive uses two magnets, one positioned in front of each other. The coil actuator is positioned between these magnets. In the Figure 2 can be seen highlighted in the position of the neodymium magnet and coil actuator in a hard disk. These used to develop the prototype.

2.4. Idealization of the prototype

The inductor of the hard disks forming an angle of 90 ° between the magnetic field and the length of the active inductor. This makes it has a maximum induced voltage.

he magnets present in hard disks have two different poles on each side Figure 3a was chosen for this reason the construction illustrated in Figure 3b, which does not separate the two magnets on the existing part.

This constructive aspect eliminates the use of diamond wheels for cutting of magnets. Cutting produces waste and rust, weakening the magnet. The magnetic properties of magnets are also influenced when cut because heat generated.



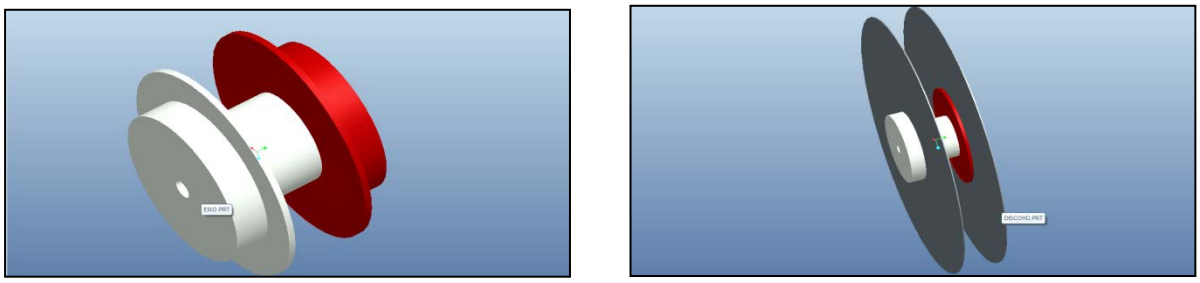
a) Face field of the magnet **b) Sectional view of the idealized**

Figure 3 – Field magnet and sectional view of the idealized single-phase synchronous generator

2.5. Project support shaft and 3D software

To aid in the idealization of the permanent magnet generator prototype, 3D design software for subsequent mechanical construction was used.

In Figure 4a is the representation of the axis and mounted supports. The bearing is fixed on the shaft (white part). After mounting the shaft with the support was mounted disks on the prototype which will be fixed the magnets (Figure 4b).



a) Backing mounted **b) Mounting disks**

Figure 4 – Mounting software

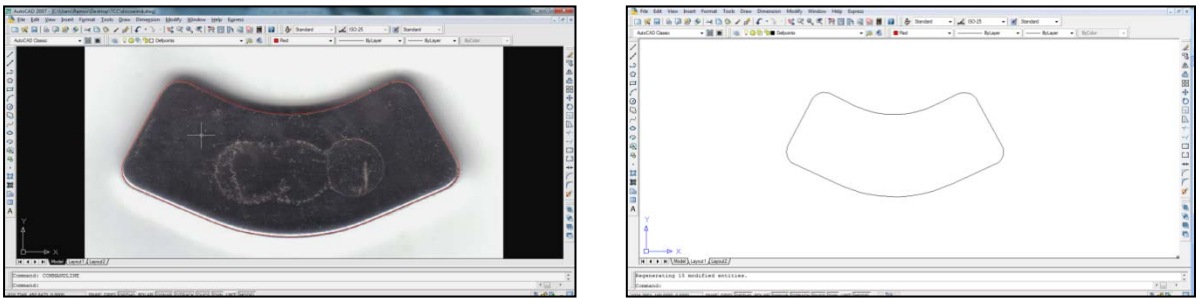
2.6. Design placement of magnets

Neodymium Iron Boron permanent magnets should be equally distributed, keeping the same distance apart. This preoccupation is due to do the correct position of the magnets poles, conductors and weight distribution on the data disk.

The *software AutoCAD* has a tool that imports images. The software allows you to import pictures and use the drawing tools over the image. Knowing this a common residential scanner was used to acquire an image of the magnet.

The scanner scans the image to scale automatically when imported the same for AutoCAD is only necessary to paste the image in 1:1 scale.

With the image in Autocad held the magnet contour using the software editing tools. The contours were done in red for better visualization in *AutoCAD* (Figure 5a). Show in Figure 5b just the contour of the magnet.



a) Contour of the magnet ready **b) Block with lines used in contour**

Figure 5 - Contour of the magnet

After drawing the outline of the data disk and the outline of the magnet broke for the distribution of magnets. The magnet placed at a distance of 30mm. With the aid of the tool Polar Array made the distribution of the four magnets.

The same method was used to design the correct placement of the windings. In Figure 6 is shown the position of the magnets on disk and the windings phenolite plate.

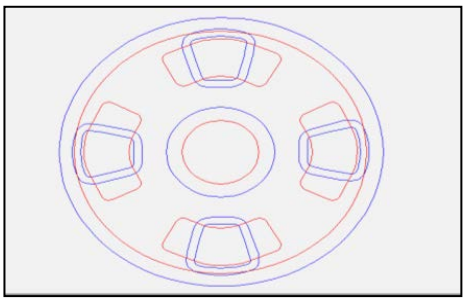


Figure 6 – Windings positioned

2.7. Retirada dos enrolamentos dos atuadores

The windings of the actuators that have been used in the prototype are fixed on actuators with a thermoplastic, Figure 7a.

The removal of the thermoplastic was performed using chloroform (CHCl3), which does not react with the varnish of the winding. The actuator was immersed for one day in the product, being the coil fully independent of the actuator. Figure 7b.



a) **Winding in the actuador** b) **Winding separate of actuador**

Figure 7 - Withdrawal winding of actuador

The removal of the varnish on the terminals coil was not possible only with the burning of varnish and sandpaper, because the thin wire to be just breaking ends up breaking. Thus concentrate sulfuric acid was used with the aid to removal the varnish.

2.8. Construction of the prototype

After the projection of the supports for disks hard drive next step is the construction thereof.

For the construction of the supports two different materials were used. One of the materials is a white billet of Teflon, the other stuff is a red billet polyurethane, oth cylindrical, easy machining and non-magnetic.

2.9. Positioning and fixation of magnets

With the design in AutoCAD the next step was the positioning and fixation of magnets in the data disk. O *AutoCAD* permite a impressão em escala 1:1 do desenho.

For the positioning of the magnet is necessary to use some kind of mold, because while there is no cure glue, they attract each other out of the prescribed position.

Cut paper was used, because in this way has a small relief to assist the positioning of magnets.

So that the magnets do not exceed the significant relief while curing of the glue, the data disk is placed on a magnetic surface where the magnets create a magnetic force against the disk data (Figure 8).



Figure 8 - Collage of magnets on metal surface

The *Localite Araldite* was used because it has a power of great power and a little glue curing time.

2.10. Fixing the stator windings and assembled prototype

A plate of phenolite with circular shape, larger than the data disk diameter (105mm) was used to build the stator The center has bearing diameter, 35.5 mm. Thus the bearing fits inside the stator where the windings are.

Figure 9 shows the stator with winding already fixed, the prototype bearing in its center and the support of the prototype already fixed. The windings were fixed with the aid of hot glue to facilitate handling.

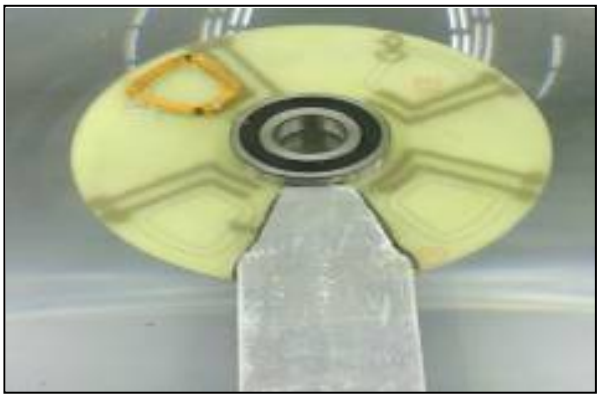


Figure 9 - Construction of the stator of generator

The prototype in its final form, along with the engine used for your mechanical drive can be seen in Figure 10. The discs are not stuck in the holder, because after placement of magnets they magnetically attract and be fixed in position.

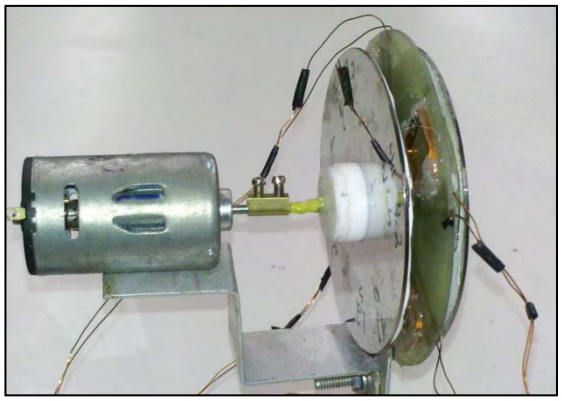


Figure 10 - Prototype and mechanical drive

2.11. Measurement of the winding wire size and number of turns

With the aid of a caliper the wire winding diameter was measured. Diameter 0.25 mm was found. Referring to the table of enamelled wires, [13] the following information in accordance with Table 01 was found:

Table 01 – winding diameter

AWG	Section (mm)	Diameter (mm)	Nominal Ampere. @20ºC
30	0,0507	0,254	0,15

Once determined the wire, the rated current of the generator was set at 150 mA, considering the 4 windings connected in series.

Counting the number of turns of the coil was done manually. The total of one winding is 210 turns of wire.

3 RESULTS

3.1. Waveform of the induced voltage

With the magnetic flux already determined, is analyzing the waveform of the induced voltage in the windings of the generator running at constant speed. The Figure 11 illustrates the waveform of the induced by the passage of the magnet by a coil voltage during a cycle The blue arrow indicates the direction the magnets are moving. For the analysis we considered the active conductors.

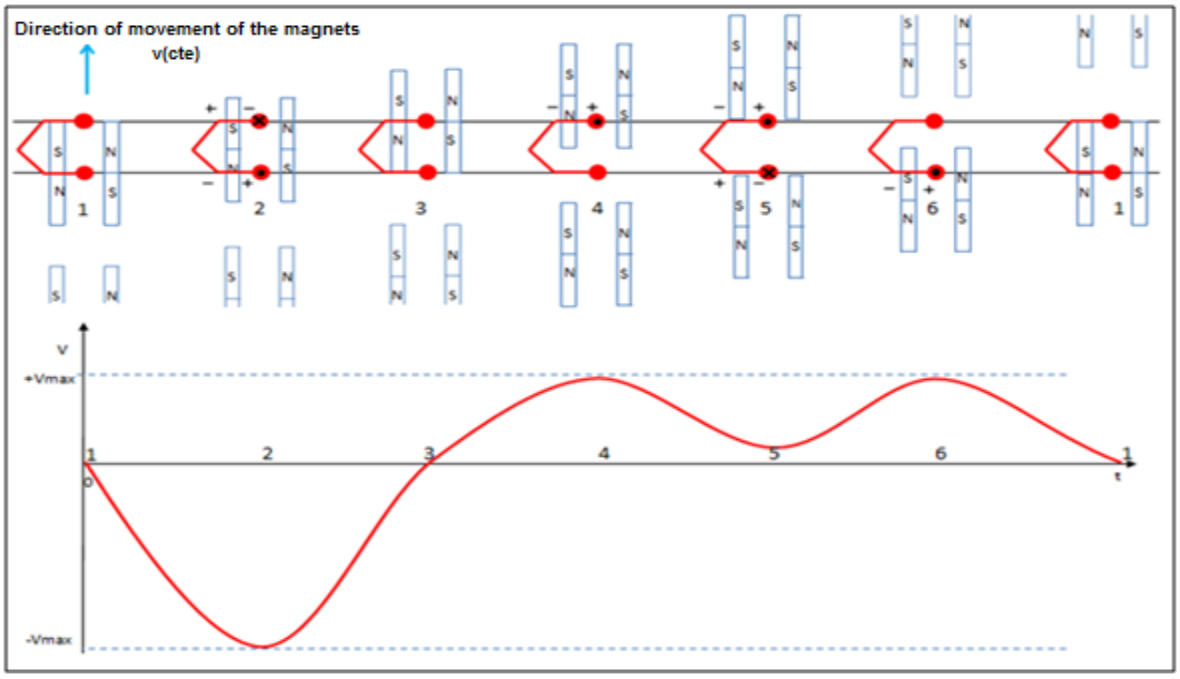


Figure 11 – Theoretical voltage in a stator winding

Steps are listed in Figure 11 the main variations of the theoretical voltage induced in the stator allow for the explanation.

Step 1: The voltage induced in the stator is equal to zero, because both extremities of the conductor are influenced by the same magnetic field direction and intensity.

Step 2: It is where most negative voltage induced in winding the conductor occurs The two extremities of the conductor are embedded in the fields of opposite directions, thereby providing the sum of the voltages induced in the active conductors.

Step 3: Similar to Step 1.

Step 4: Maximum positive voltage (lower than the negative), only the top end of the conductor lies immersed in the field, but the other end is without influence of magnetic field.

Step 5: Both extremities of the conductors are with a slight influence of stray magnetic fields because they are not totally immersed in them. The flows of the magnetic fields are oppositely directed at each extemity. Thus, there is a small induction voltage.

Step 6: Similar to Step 4.

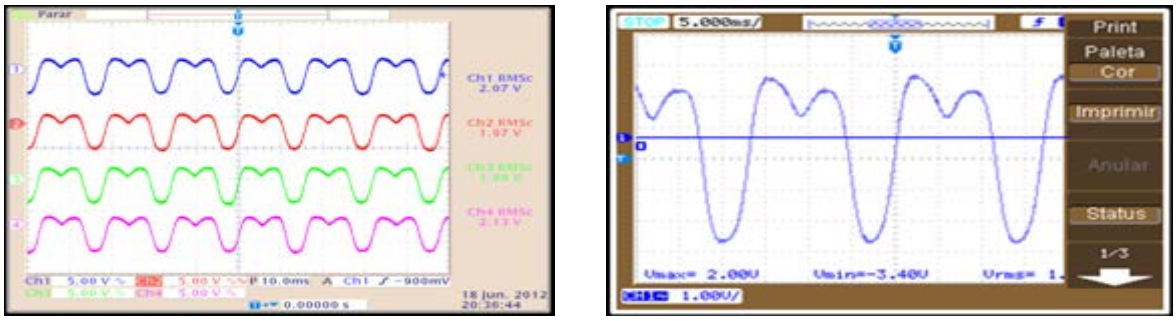
Following analysis of the resulting waveform is noticed that it is not possible to use the prototype generator connected directly to AC equipment for not having a perfect sine.

Wind turbines usually have AC generators. As the wind speed is not constant the frequency of the wave generator resulting is unstable, preventing the connection of these devices directly into CA. This occurs independent of the resulting wave is a perfect sine. Therefore, it is very common to use alternating current rectifiers for DC in the output of wind turbines. With this prototype should be provided with a rectifier of alternating current to direct current.

3.2. Voltage induced in the windings

For conducting practical tests 6V DC motor was used s. The Figure 33a illustrates the waveforms of the induced voltage obtained from the four stator windings, it is observed that the waves aren't lagging with each other and they became very close with effective stress.

The induced theoretical voltage view in Figure 11a was confirmed in the practical as best seen in Figure 12b, where the axis yellow is 0V tests.



a) Voltage induced in the four stators **b) Voltage induced in a stator**

Figure 12 – Real induced voltage

Since the waves are occurring at the same time for each of the four windings, was chosen by the association inseries. Thus there will be a summation of the effective induced voltages (Figure 13).

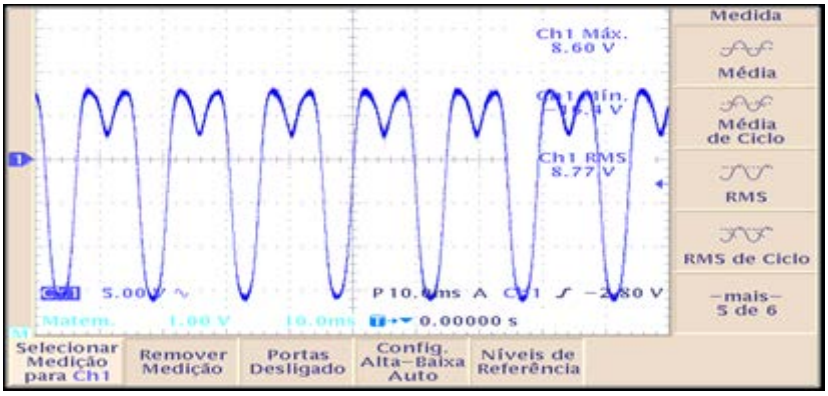


Figure 13 - The resulting waveform with four windings in series

3.3. Experimental result of effective theoretical tension

Spectrum analysis was performed using the FFT function of the oscilloscope and the four coils in series is illustrated in.Figure 13.

By analyzing the resulting spectrum is possible to verify that to a frequency of approximately 69Hz of the resultant wave, the fundamental wave has an effective voltage of 6.8 V. The second harmonic present an effective voltage of 4.4 V at a frequency of approximately 138Hz.

Knowing that the voltage of each wave is given by equation 1:

$$\text{Vef} = \frac{1}{2\pi} * \int_0^{2\pi} Vp^2 * sen^2(wt) * dwt \quad (1)$$

Has the total RMS voltage of the two waves, fundamental and second harmonic is:

$$\text{Vef} = \sqrt{Vef1^2 + Vef2^2} = 8{,}09V \quad (2)$$

The voltage was found is very close to the voltage found in practice using the RMS function of the oscilloscope (see Figure 14 in red).

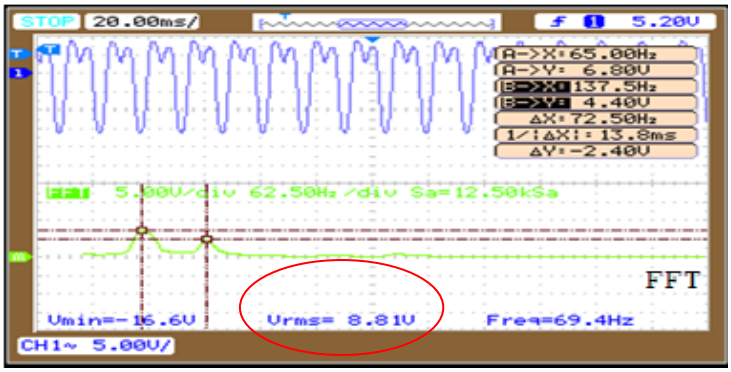
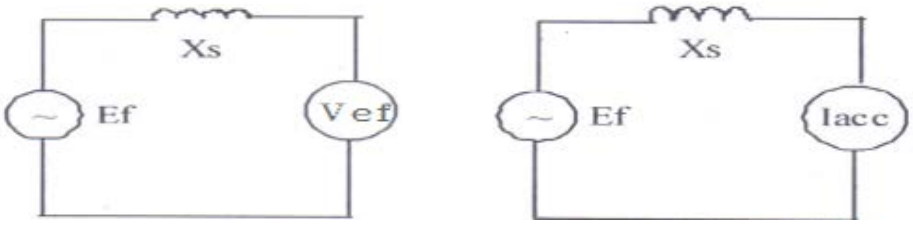


Figure 14 - The resulting waveform Vrms=8,81V to 69Hz

3.4. Determination of synchronous reactance

With the determination of the short-circuit of the generator and the no load with a constant rotation of the generator, is possible to determine the reactance present in the generator. Thus it is possible to determine the load which will permit removal of the largest power generator.

To test the generator, the rotation of the generator was set at 1200rpm. In this rotation the voltage (Vrms) of the generator at no load is 9.8 V. The short-circuit current (IACC) in the same rotation is 206mA.



a) Measurement of no-load voltage **b) Measurement of the current short-circuit**

Figure 15 - Circuitry for determining the synchronous reactance

Thus, from equation 3 it is possible to determine the reactance of the synchronous generator.

$$\text{Xs}(\Omega) = \frac{Vef(V)}{Iacc(A)} = 47{,}57\Omega \quad (3)$$

3.5. Determining Power

To obtain the maximum power of the generator, its charge will have the same reactance impedance, or 47.57 ohms. Thus, the rotation of 1200rpm generator delivers a maximum power according to equation 4.

$$\text{Pmax} = Vef(V) * Iacc(A) = 2{,}018W \quad (4)$$

For determining the nominal power of the generator in the same rotation about 1200rpm, it's considers the nominal current of the generator in case of 0.150 mA as determined in section 3.5. Thus it is calculated according to equation 5.

$$\text{Pnom} = Vef(V) * Inom(A) = 1{,}47W \quad (5)$$

4. CONCLUSION

The main objective of the analysis of a single phase permanent magnet synchronous generator using components of hard drives has been reached.

The analyzed of prototype waveform would not allow to connection the prototype directly into alternating current equipment. However, the use is possible when the generator has a wave rectified to direct current.

ACKNOWLEDGMENT

At the Federal University of Rio Grande do Sul, mainly the Laboratory of Mechanical Manufacturing (LDTM) for providing the material and technological resources. Bodies CAPES, CNPq and FAPERGS for supporting the project and investment in research.

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ENERGY COST REDUCTION FOR ELECTRONIC INDUSTRY:

A CASE STUDY OF HDD INDUSTRY

Pachanee Rittiboon
Energy Technology and Management (M.Sc.), Graduate School – Interdisciplinary Program,
Chulalongkorn University, Thailand
E-mail: Mercedy@gmail.com

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E-mail: Mercedy@gmail.com

Abstract

The advancement of technology has developed rapidly contributing to the growth and competition in the hard disk industry. The demand for hard disk drives promotes competition between companies thus accelerating the product development through: enhancing the quality of the product, investment research, innovation and new technologies, and reducing production costs, such as reducing the amount of waste. One common way to reduce costs is to assess and reduce waste resulting from the manufacturing process. Another popular way to reduce costs is by improving the energy efficiency of the plant.

The purposes of this study was to determine how to reduce the energy costs of the electronics industry; a case study for the hard disk drive industry. Statistical techniques were used for root case analyze, to measure the energy consumption, and to validate and monitor the results. The specific energy consumption (SEC) was one indicator used to visualize the increase in energy consumption with a clear trend showing that production of 1 HDD unit now consumes more electrical power than in the past. A cause and effect matrix and Why - Why analysis chart were used to explain that the problem of high energy consumption in the HDD industry comes from the system management and use of new technology in the HDD products. The focus for solving these issues is to improve the efficiency and energy consumption management of the HDD industry.

To reduce energy the consumption and improve the efficiency of the HDD manufacturing process

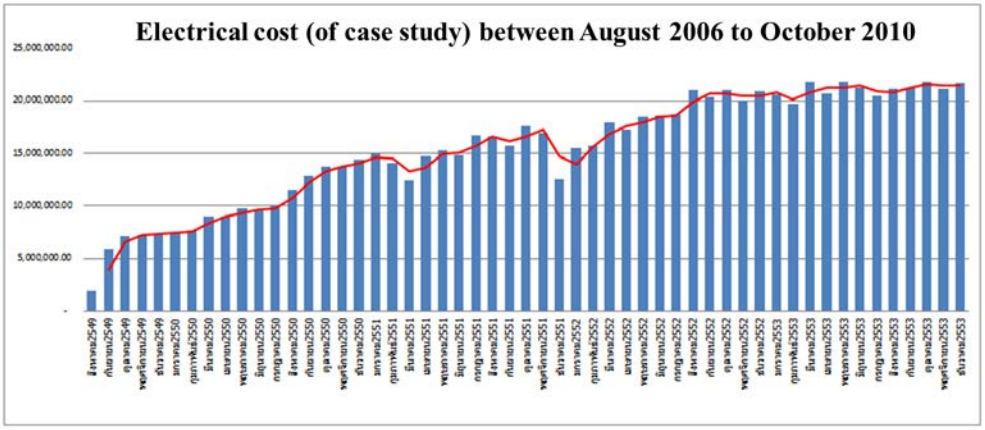
5 measures were chosen.

The first measure is employee education; proper training and collaboration from employees is very important for sustainable energy cost reduction. The second measure is efficiency improvement; the current largest consumer of energy is the HVAC (Heating, Ventilation and Air Conditioning) system. Implementing a new High-Efficiency Chiller system to replace the current HVAC system can reduce electrical costs by approximately 8.3Million baht/year. The third measure is to create a sequencing plan for chiller operation based on efficiency. This plan ensures the least efficient chillers are only used during high load demands reducing electrical consumption with no additional costs. The fourth measure is minimizing compressed air leaks; any leaked air is wasted and still costs the industry money. Reducing the amount of leaked air will save the industry approximately 2 hundred thousand baht per year. Finally, the fifth measure is evaluating the amount of required lighting Removing fluorescent lights in over lit areas is required for energy saving. This measure can reduce energy costs by approximately 6.3 hundred thousand baht per year. Moreover, the approach in this paper also can be a guideline for the electronics industry to evaluate their current state of energy consumption and set targets for energy reduction by choosing measures and maintaining good energy management.

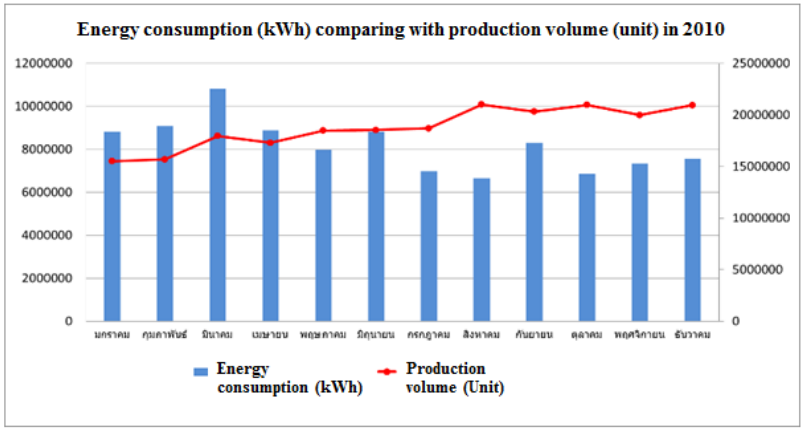
Keywords: Energy cost reduction, Energy saving, Energy consumption.

1. Introduction

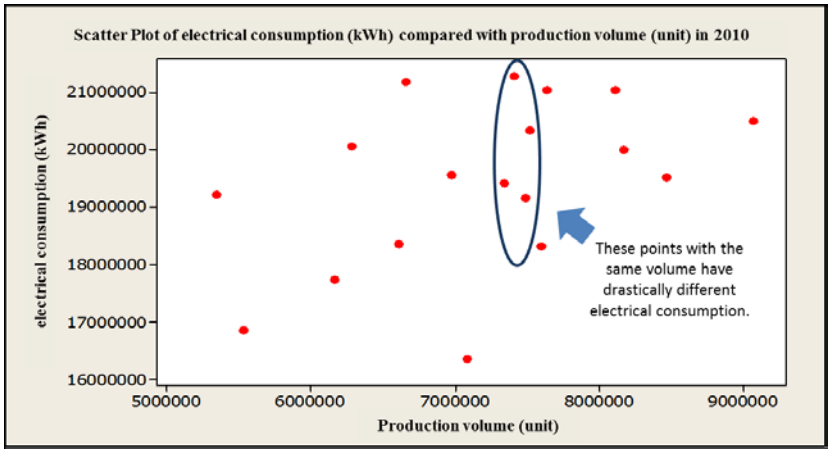
The hard disk drive industry consumes large amounts of energy in the production, operation and the testing of each product.



Graph show electrical cost (of case study) between August 2006 to October 2010. The above graph indicates the expected yearly increase in cost associated with the plants energy consumption.

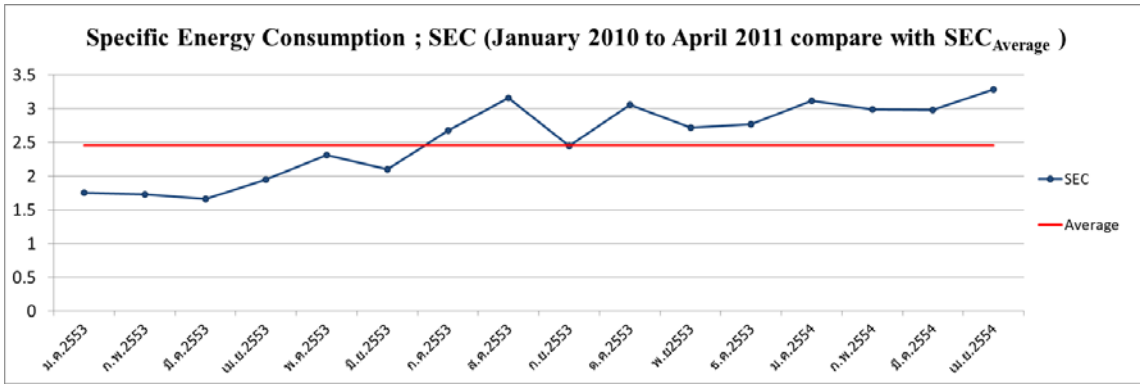


The above graph presents the amount of electrical consumption (kWh) compared with production volume (unit). Although the production of HDD has decreased, the amount of energy consumed in the plant continues to rise. To demonstrate the relationship between the production of hard disk drives in 2010 and electrification of factories during the same period, a scatter plot was created which clearly shows that some months with the same production volume have different electrical consumptions. The months with higher power consumption are producing more waste.



Scatter Plot of electrical consumption (kWh) compared with production volume (unit) in 2010

The scatter plot clearly shows that points with the same volume have drastically different electrical consumption. This means the electrical energy consumption is not consistent with the production quantity due to a combination of many factors such as: the expansion of the plant, the types of products produced each month, the increase in testing duration for larger capacity drives, and the degeneration of tools and machinery. Research is therefore needed to identify the root cause of this discrepancy to formulate an effective solution.



Graph presents the Specific Energy Consumption; SEC during January 2010 to April 2011 compare with $SEC_{Average}$ at the same period

As seen in the above graph, there is an increasing trend for the SEC and which could result in a $SEC_{Average}$ = 3.5 kWh/Units if no energy management system is implemented.
For this reason a case study is required to identify the root cause of increasing energy consumption in the HDD industry. The research will focus on the factors that affect energy consumption and determine the energy conservation measures for energy cost reduction.

2. Expected benefit

1 To create a guideline and methodology to evaluate the energy efficiency and energy consumption of the electronics industry.

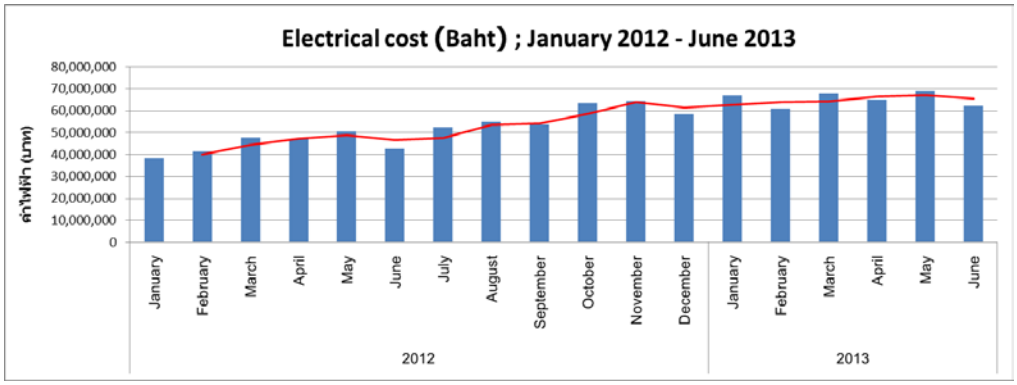
2 To understand the current status and energy consumption of the hard disk drive industry.
3 To evaluate the potential energy conservation for energy saving.
4 To reduce the energy costs of the hard disk drive industry.

3. Research procedure

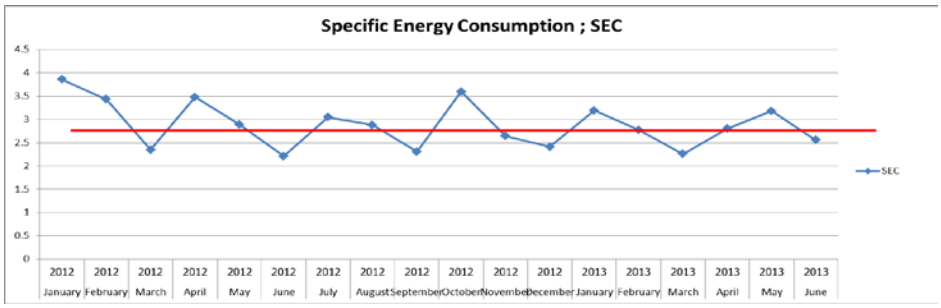
1 Evaluate the energy consumption and energy management of a case study.
2 Review data and set a target for energy cost reduction.
3 Identify the root cause and factors that affect the energy cost.
4 Provide energy conservation measures to achieve the targets.
5 Implement a plan and compare the energy cost before and after implementation.

3.1 Evaluate the energy consumption and energy management of a case study.

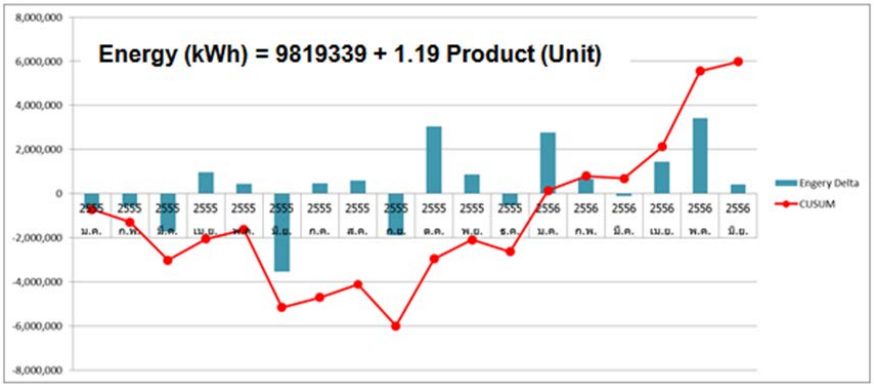
Information was collected by measuring a building's energy performance and electrical record for a period of at least 18 months. The first graph shows that the case study has an increasing trend of electrical cost.



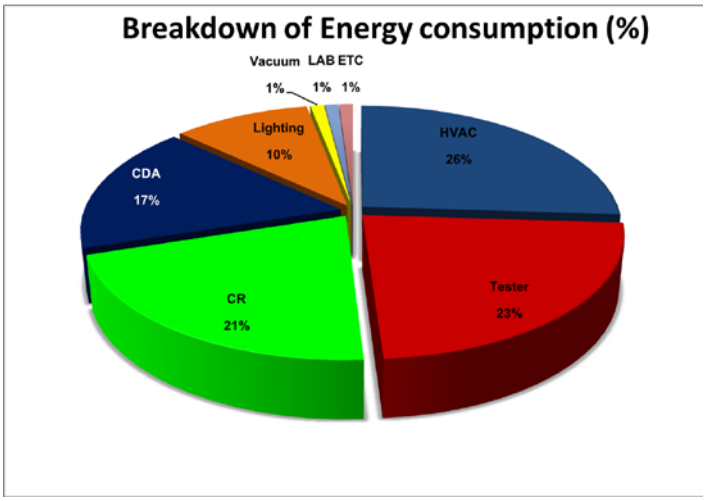
The SEC graph provides information about the energy consumption per unit hard drive. Comparing the SEC graphs from 2012 and 2013 it is clear that the $SEC_{Average}$ of 2013 is less than the average from 2012 but the graph still not stable; there is room to improve the energy consumption.



The best method to monitor the energy consumption is to create a cumulative sum of different chart (CUSUM). Analyzing the electrical energy consumption and hard disk production from last 18 months revealed that from October 2012 onward the CUSUM control charts have a positive slope. This indicates that the industry lacks energy-saving techniques and there is an opportunity to improve the energy consumption.



The top 5 energy consumers in this industry are HVAC, backend testing, clean room assembly, the Compressed Dry Air System and lighting. These factors can serve as a starting point for setting goals and procedures for energy cost reduction.



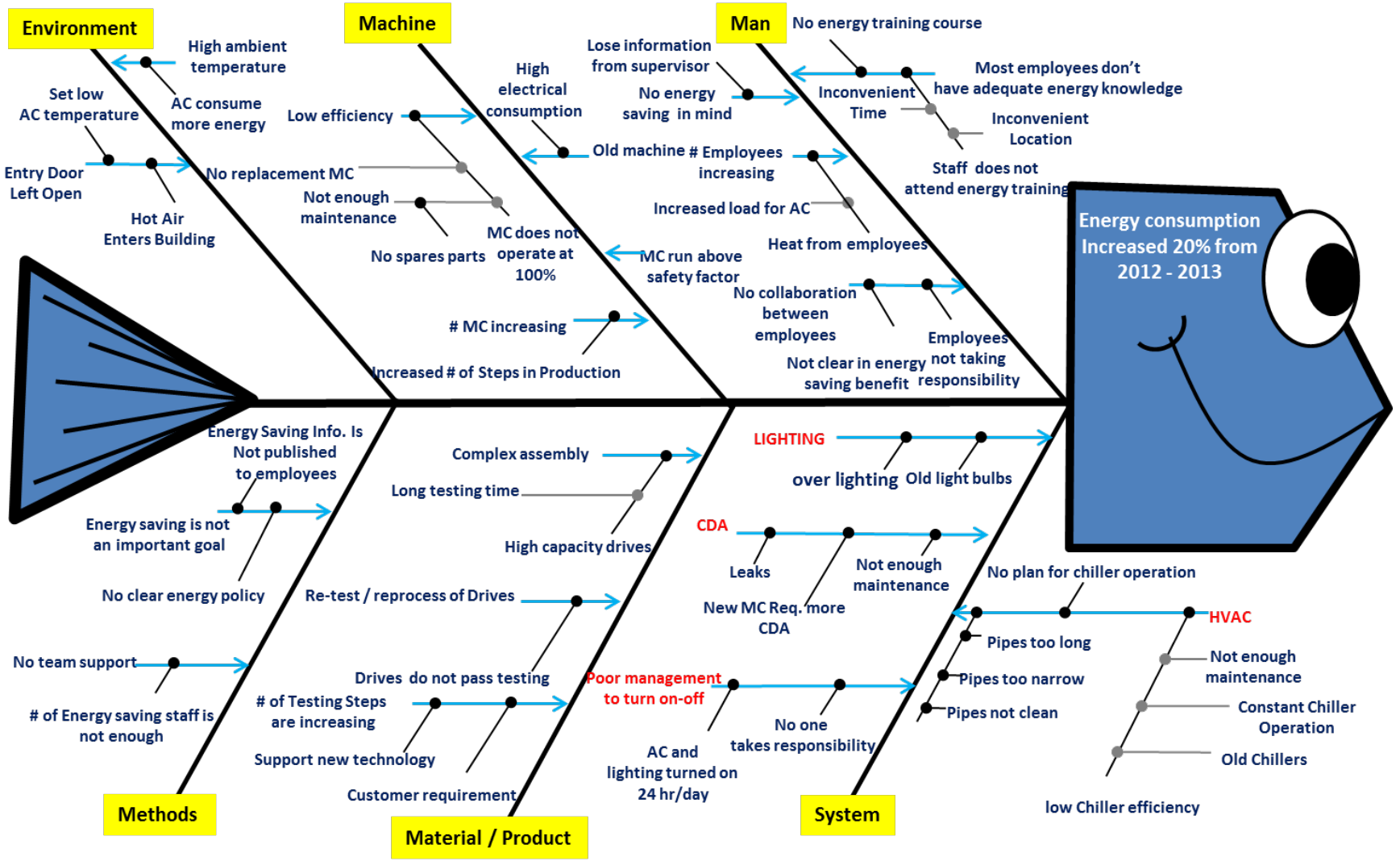
3.2 Review data and set a target for energy cost reduction.

Referring to the energy consumption and energy baseline data an opportunity was foreseen to review and set a target for the reduction of energy consumption. The aim of this report is to reduce cost of energy consumption from the baseline in 2012 - 2013 (January-June) by at least 1 million baht, or 1-2 % of the total energy cost. The SEC reduction will also be included after implementing the proposed measures.

3.3 Identify the root cause and factors that affect the energy cost.

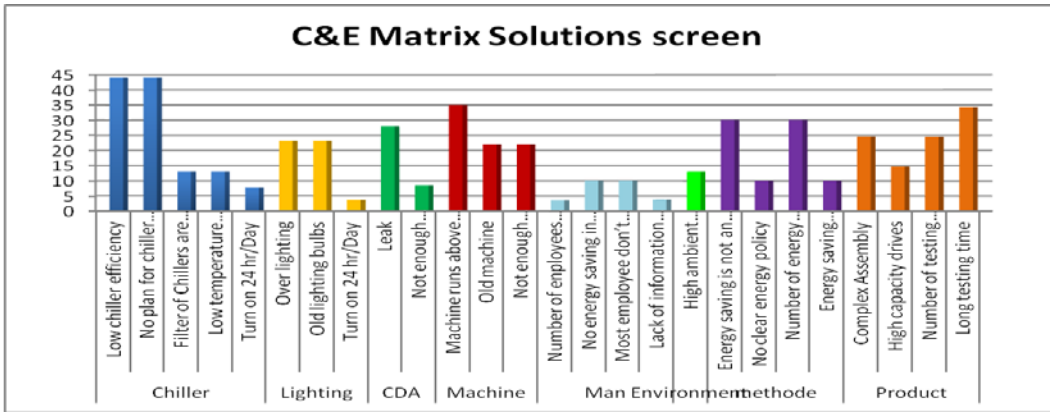
The Cause & Effect diagram and Why – Why analysis statistical tools were used to identify the root causes of the increasing energy consumption trend and generate potential solutions.

C&E Diagram


Environment
High ambient temperature
AC consume more energy
Set low AC temperature
Entry Door Left Open
Hot Air Enters Building
No replacement MC
Machine
Low efficiency
High electrical consumption
Old machine
Not enough maintenance
No spares parts
MC does not operate at 100%
MC run above safety factor
MC increasing
Increased # of Steps in Production
Man
No energy training course
Lose information from supervisor
No energy saving in mind
Inconvenient Time
Most employees don't have adequate energy knowledge
Inconvenient Location
Staff does not attend energy training
Employees increasing
Increased load for AC
Heat from employees
No collaboration between employees
Not clear in energy saving benefit
Employees not taking responsibility
Energy consumption Increased 20% from 2012 - 2013
Energy Saving Info. Is Not published to employees
Energy saving is not an important goal
No clear energy policy
No team support
of Energy saving staff is not enough
Methods
Complex assembly
Long testing time
High capacity drives
Re-test / reprocess of Drives
Drives do not pass testing
of Testing Steps are increasing
Support new technology
Customer requirement
Material / Product
LIGHTING
over lighting
Old light bulbs
CDA
Leaks
Not enough maintenance
New MC Req. more CDA
Poor management to turn on-off
No one takes responsibility
AC and lighting turned on 24 hr/day
System
No plan for chiller operation
HVAC
Pipes too long
Pipes too narrow
Pipes not clean
Not enough maintenance
Constant Chiller Operation
Old Chillers
low Chiller efficiency

The schematic representation of cause and effect (C & E Diagram) above shows that, there are various factors that contribute to increasing the energy consumption of the studied building when compared to the base year (2012. This influence from multiple factors indicates that the priority of all variables is important. These variables can be separated into a cause and effect (C & E Matrix). A rating for the importance of each variable is assigned to achieve a weighted ranking to easily select the topic for development.

item	Cause	Severity	HVAC	Tester	CR	CDA	Lighting	Vacuum	Total
			2.6	2.3	2.1	1.7	1.2	0.1	
Chiller	low chiller efficiency	9	x	x					44.1
	No plan for chiller operation	9	x	x					44.1
	filter of Chillers are not clean	5	x						13
	low temperature adjustment	5	x						13
	turn on 24 hr/Day	3	x						7.8
Lighting	over lighting	7			x		x		23.1
	old lighting bulbs	7			x		x		23.1
	turn on 24 hr/Day	3					x		3.6
CDA	Leak	7		x		x			28
	not enough maintenance	5				x			8.5
Machine	old machine	5		x	x				22
	machine runs above safety factor	5	x	x	x				35
	not enough maintenance	5		x	x				22
Man	Most employee don't have adequate energy knowledge	1	x	x	x	x	x	x	10
	lack of information transfer from supervisor	1	x			x	x		5.5
	No energy saving in mind	1	x	x	x	x	x	x	10
	Number of enployees is increasing	1	x				x		3.8
Environment	high ambient temperature	5	x						13
methode	energy saving is not an important goal	3	x	x	x	x	x	x	30
	Number of energy saving staff is not sufficient	1	x	x	x	x	x	x	10
	No clear energy policy	3	x	x	x	x	x	x	30
	Energy saving information is not published to employees	1	x	x	x	x	x	x	10
Product	Complex Assembly	3	x	x	x		x		24.6
	high capacity drives	3	x	x					14.7
	number of testing steps is incresing	5	x	x					24.5
	Long testing time	7	x	x					34.3



WHY-WHY analysis (of each section),

Why Why Analysis : there are trend increasing of electrical consumption when compare with baseline (2012)						
Detail	**WHY - 1**	**WHY - 2**	**WHY - 3**	**WHY - 4**	**WHY - 5**	**Action**
System - Chiller	Chiller efficiency decreased	Chiller have long life-cycle	Low frequency maintenance	Equipment deterioration		1.Replace the low effeiciency Chiller with new models. 2.Increase the frequency of maintenance.
	No plan for chiller operation	Operate all chiller for safety factor	Operate chiller low effeiciency as normal			1.Plan to stop the low chiller efficiency 2.Increase the plan operation for high chiller effeiciency
System - Lighting	Unnecessarily lighting in some area	Change working area	Install the lighting bulbs without standard comparing			1.Compare Lighting level (lux) and number of bulbs with standard lighting 2.Reduce the over bulbs when comparing with standard
	Old Bulbs Techanology(T8)	High energy consumption when compare with T5 or LED				1. Study the concern and limitation of LED 2. Replace the T8 deteriorated bulbs with LED
System - CDA	Compress air is not enough for operation	Leak issues in CDA system	CDA systen malfunctioning, Joint wear loose etc.	Low frequency maintenance		1. Verify the leak point and fix it. 2. Increased monitoring and maintenance.
Machine	High safety factor	Prevent tool issues				1. Consider the best setting for safety factors. 2. Study chiller efficiency
Man	Employees don't have adequate energy knowledge	No energy training course				1.Promote Energy saving activity to employees. 2.Set Energy training course for employees
	No collaboration between employees	Employees not taking responsibility	Not clear in energysaving benefit			1.Public the benefit of energy saving 2.Set goal for support energy saving project.
Environment	High vambient temperature	AC consume more energy				1.Control time to turn on- turn off AC.
Methode	Energy saving is not important goal					1.Set Energy Baseline 2.Create energy consumption goal
	No clear energy policy	lack of performance evaluation				1.Review energy policy
Product	Long testime	High capacity drives	Complex function testing			1.Study how to reduce test time.

3.4 Provide energy conservation measures to achieve the targets.

After discovering the causes for the increased energy consumption, measures should be provided to resolve the energy problems. These measures must be able to effectively reduce the energy consumption, reduce costs and be consistent with the goals and sustainability of the factory.
The implementation phase should begin with energy saving training or energy management in the factory so that all employees are aware of the importance of energy management and raise general awareness.
The chosen measures should be applied in the factory, be accepted by all employees, clearly show results after implementation and not affect the factory production.

The below matrix is an example of how to determine the measures that should be chosen based on the cost benefit of each solution once the root cause has been discovered.

1. High result and Easy to implement.
2. Low result and Easy to implement.
3. High result and difficult to implement
4. Low result and difficult to implement.

Note: The dark green measures should be chosen for implementation first, followed by light green, then yellow and finally red.

ตัวอย่างมาตรการและการลำดับความสัมพันธ์		
ได้ผลสัมฤทธิ์สูง	เพิ่มความถี่ในการตรวจสอบและบำรุงเครื่องจักร วางแผนโหลดโดยคำนึงถึงประสิทธิภาพเครื่องจักรร่วมด้วย ตรวจสอบรอยรั่วและแก้ไข (CDA) พิจารณาความเหมาะสมของแสงสว่างและลดจำนวนหลอดไฟที่ไม่จำเป็น ใช้บัลลาสต์กำลังสูญเสียต่ำ ลดความดันอากาศอัด(CDA)ให้เหมาะสม ลดอุณหภูมิอากาศก่อนเข้าเครื่องอัดอากาศ ล้างเครื่องปรับอากาศ	เปลี่ยนเครื่องจักรใหม่ที่มีประสิทธิภาพสูง ลดเวลาทดสอบชิ้นงาน ปรับเปลี่ยนขนาดท่อระบายความร้อนให้เหมาะสม (HVAC) เปลี่ยน Chiller ใหม่ เปลี่ยนหลอดไฟเป็น LED ปรับปรุงประสิทธิภาพกระบวนการผลิตให้ดียิ่ งๆขึ้น เปลี่ยนหลอดไฟ T8 เป็นหลอด T5 ร่วมกับโคมสะท้อนแสง ปรับปรุงชุดระบายความร้อนของระบบทำความเย็น
ได้ผลสัมฤทธิ์ต่ำ	อบรมพนักงานเกี่ยวกับการอนุรักษ์พลังงาน จัดกิจกรรมและบอร์ดแสดงความรู้เกี่ยวกับการอนุรักษ์พลังงาน ปรับค่า Setting ให้เหมาะสม (ลด Over srtting) ตั้ง energy saving mode screen สำหรับจอคอมพิวเตอร์ ตรวจสอบและสังเกตุการใช้พลังงานของโรงงาน ตั้งเวลาเปิด ปิด ไฟหน้าอาคาร ทางเดิน และลานจอดรถ ศึกษาดูงานที่โรงงานตัวอย่าง ปิดสวิตช์ไฟ-แอร์ เมื่อไม่ใช้งาน ลดเวลาการใช้เครื่องปรับอากาศ	ปรับเปลี่ยนกระบวนการผลิต เพื่อลดความร้อนสะสมในห้องสะอาด เปลี่ยนผังเครื่องจักรเพื่อลดความร้อนสะสมและการระบายความร้อนในส่วนท้ายการผลิต
	ทำได้ง่าย	ทำได้ยาก

3.5 Implement as a plan and comparison the energy cost before and after implement.

The 5 measures chosen to reduce energy consumption and improve the efficiency of the HDD manufacturing process are:

3.5.1 Energy training for Staff employee education.

In order for the suggested measures to be effective and receive support from the employees, the primary concern for management should be to set activities and training courses to educate and promote energy saving to all staff members.

The targeted employees belong to 3 groups; the first is operators, the second is engineers and officer workers and the last group is experts and the energy committee.

3.5.1.1 Policies training and energy conservation awareness program in the factory for new employees.

Objective

- To publish a list of the Energy Conservation Board of Directors along with the plant's energy conservation policy to new employees.
- To make employees aware of the energy conservation policies in the organization and to further expand their knowledge on the companies energy conservation activities.
- Provide a good conscience to employees by pointing out the benefits of energy conservation in the plant.

Target group Arrange training classes for new production employees every month,
200 person / month.

Operating period 3 months

Project evaluation and data collection method

Collect data for the conclusion of the project by distributing questionnaires to the participants to assess the project of “Policies training and energy conservation awareness program in the factory for new employees”.

3.5.1.2 Energy Management Project

Objective

- To understand the requirements of the ISO 50001:2011 standard for the energy management system in the factory.
- To discover the solutions in order to save energy in the plant.

Target group Provide training to engineers and office staff 50 persons (4 rounds)
Total 200 persons.

Operating period 3 months

Project evaluation and data collection method
Collect data for the conclusion of the project by distributing questionnaires to the participants including the completed tests from before and after the training class to assess "Energy management in factory".

3.5.1.3 Energy Management Technique for industry Training Project

Objective

- To determine how to evaluate the energy efficiency of the plant.
- To prepare and set the Baseline and Indicators of energy.
- To evaluate the energy savings for each system.

Target group The Company's energy experts, the Committee of Energy Conservation and anyone interested or involved in this project, 40 person.

Project evaluation and data collection method
The participants must achieve a score of over 80% from the training activities and final test to become qualified The information collected through this assessment will be keep for the project conclusion.

3.5.2 Efficiency improvement in HVAC (Heating, Ventilation and Air Conditioning) system by replacing a the current Chillers with new High-Efficiency Chillers.

The Air cooled Chillers in this case study were very old, and have been in operator for 9 years.
When compared with other chiller found 2 airs cooled chillers are lowest efficiency chillers.
If the current 2 Air cooled Chillers are replaced with water cooled Chillers, the Electrical consumption will be reduce by a total of 8 million baht per year with a payback period of only 1.7 years.

Objective

- Optimize cooling performance.
- Reduce maintenance costs.
- Reduce the electrical power consumption.
- Reduce problems arising in the performance failure of the refrigeration system.

Principle and Rationale
The test building's electricity consumption on the production floor was observed for 1 month revealing that the heat exchange and ventilation system was the highest power consumer compared to all other sources. The current facilities use 2 Air cooled chillers with a very high energy consumption per ton of cooling; therefore, the Air cooled chillers should be replaced by the Water cooled chillers with the low energy consumption per ton of cooling (high performance).

Methods

Improve the Chiller efficiency by changing from Air cooled to Water cooled, 1 machine at Chiller plant room.

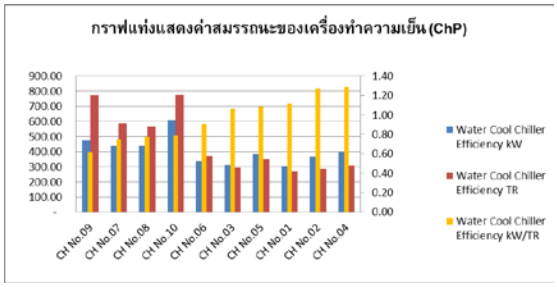
Previous issue of equipment and systems

It was observed that the efficiency of air cooled chiller was relatively low compared to the water cooled Chiller because the Air cooled Chiller in the plant has been operating for more than 9 years and the Air cooled Chiller has a lower rated efficiency than Water Cooled Chiller.

3.5.3 Create a sequencing plan of chiller operation based on efficiency.

According to the data collected from the factory, many of the Chillers are not running at full capacity constantly so there is no need to run all of the refrigeration machines at all times. During the periods of lower production, the Chillers with the highest efficiencies should be chosen to operate. This can reduce the energy consumption and cost in the factory. The efficiency of each Chiller should be evaluated and checked to determine a plan of operation for the machines.

Graph shows the efficiency of each chiller and Table Summarizes the Chiller specifications



ลำดับ	หมายเลขเครื่อง	Water Cool Chiller Efficiency					
		TRspec	kW	TR	kW/TR	ค่าสัมประสิทธิ์สมรรถนะ (COP)	ค่าอัตราส่วนประสิทธิภาพพลังงาน(EER)
1	CH No.09	1,000	476.47	770.47	0.62	5.69	19.41
2	CH No.07	1,000	438.96	585.29	0.75	4.69	16.00
3	CH No.08	1,000	440.99	568.48	0.78	4.53	15.47
4	CH No.10	1,000	611.37	777.33	0.79	4.47	15.26
5	CH No.06	800	335.90	370.03	0.91	3.87	13.22
6	CH No.03	800	311.69	293.61	1.06	3.32	11.31
7	CH No.05	800	382.31	351.57	1.09	3.23	11.04
8	CH No.01	800	304.64	272.91	1.12	3.15	10.75
9	CH No.02	800	366.01	287.77	1.27	2.77	9.44
10	CH No.04	800	400.11	310.35	1.29	2.73	9.31

Principle and Rationale

Since the plant has multiple refrigeration systems there is no need to operate all of the refrigerators if there's a period of low volume manufacturing. A plan to manage the selection of refrigerators to be used to meet different demands should be created based on performance information and the energy consumption of each refrigerator. . This can help to reduce the energy consumption in the plant.

Methods

1. Evaluate and check the performance of the refrigeration system.
2. Plan refrigeration operating in terms of efficiency and energy consumption per ton of cooling.

Action plan

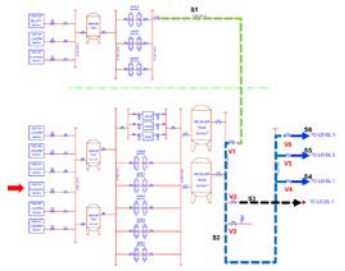
Step 1, evaluate and check the performance of the refrigeration system.

By collecting data and calculate performance of all refrigeration plants totalling 10 machines

It can be seen that by planning and sequencing the refrigerators to best meet the demand the electricity consumption and costs of energy supply to the plant can be reduced.

3.5.4 Minimizing compressed Air leaks

The results from the why – why Analysis indicate that compressed air leaks is one of the highest energy consumption factors. Observation with no load testing discovered that the air leak came from the pipe line of Production Floor (3rd floor).



เส้นทางการทดสอบ		Valve					
		V1	V2	V3	V4	V5	V6
1	S2	Close	Close	Close	Close	Close	Close
2	S2 + S1	Open	Close	Close	Close	Close	Close
3	S2 + S3	Close	Open	Close	Close	Close	Close
4	S2 + S4	Close	Close	Close	Open	Close	Close
5	S2 + S5	Close	Close	Close	Close	Open	Close
6	S2 + S6	Close	Close	Close	Close	Close	Open

The identified leakage point was fixed and a red sticker was placed for continual observation and monitoring.

Principle and Rationale

The Why - Why Analysis showed that leaks in the compressed air systems was a major contributing factor to the electrical power increase for the factory. A survey of energy consumption in the plant's compressed air system found that there were quite a lot of compressed air leaks. This large number of leaks may indicate that the frequency of maintenance is insufficient.

Operating concepts and procedures

Factories surveyed points that are leaking by testing equipment if there is a leakage of air at any certain point and inform the relevant modifies to reduce the leakage of compressed air.

The factory was surveyed to find points where leakage occurred with special testing equipment. If a leak was detected the maintenance team was informed to try and repair the leak or reduce the wasted flow of air. The most problematic points were nozzle hoses and installed fittings, variable Pressure Control devices, Control Valves, fittings and welded or sealed joints.

Methods

To use the amount of compressed air leaks test method, no-load (No-Load Testing).

1. Close all devices operating on compressed air in the system. (Shutdown)
2. Start the air compressor and timer (TON) until the compressed air pressure is up to spec, then the machine and timer will stop during TON.
3. Let the compressed air leak along the leakage points andrecord the time TOFF before the compressor will resume TON again.
4. Repeat items 2 and 3 for 3-5 trials for increased accuracy of the information.
5. Analyse the recorded time for the experiments to determine the flow rate of the leakage.

The leakage rate of the whole compressed air system was calculated to be 70.5%. Many locations were checked for leaks but it was discovered that the leaks were mainly concentrated on the Production Floor (3rd floor).

The action for leaks using Leak checking tool to surveyor detection at various points from the main pipeline of compressed air supplies system to the compressed air pressure control equipment.

The Leak Check tool surveyor was used to detect leaks at various points in the main compressed air pipeline. This pipeline runs from the compressors to the control equipment.

However, the percentage of energy savings is not high enough compared to the amount of leakage even the detection of the leak was fixed due to there've using the compressed air to the machine, such as handling the work piece, cleaning or applying compressed air to propel the cylinder at the Production Floor (3rd floor).

Suggestions

The factory should check for leaks in the compressed air system regularly using the No load test, as outlined above. These inspections will help to conserve energy because if the leaks can be detected and fixed quickly, it will help to reduce unnecessary costs. Repairing leaks will also result in the compressed air system working more effectively. The factory may prepare an audit plan for maintenance of the equipment for the compressed air generator, main pipeline, supply pipeline, valves and unit applications as well as regulate appropriate compressed air usage.

Implementation of these measures revealed that the electrical consumption can be reduced by a total of 63,951 kWh per Year with a cost reduction of 191,854 baht per year.

3.5.5 Evaluate the amount of required lighting and remove fluorescent lights over lit areas

Normally, industrial lighting is overdesigned and relocating office staff to areas which were designed for industrial specifications will cause higher than required energy consumption for lighting. The lighting needs of each area required to meet the specifications for the areas activities need to be evaluated so excess fluorescent lights can be removed.

Principle and Rationale

The design of lighting systems for manufacturing areas usually has a much higher luminance value than that of other activities. The design of the production floor and its actual usage may be modified to comply with company policies and limited space for new product development; therefore, some areas may receive luminance beyond the design expectation.

Objective

- To reduce the amount of unnecessary lighting that affects the power consumption.

Concepts and operating steps

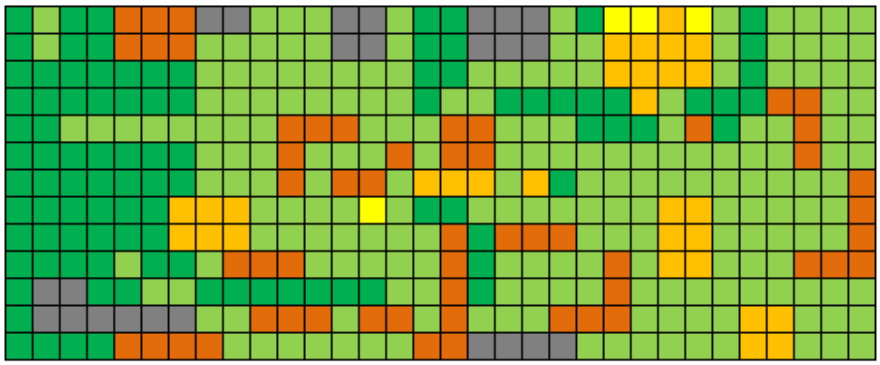
1. Reduce the number of light bulbs in areas where there is excessive lighting as following,
2. Collect luminance data of each area.
3. Compare the luminance values and activities of each area to determine if they are above specification.
4. Disconnect unnecessary lamps.
5. Analyse the results for the savings.

Step 1 Collect luminance data of each area.

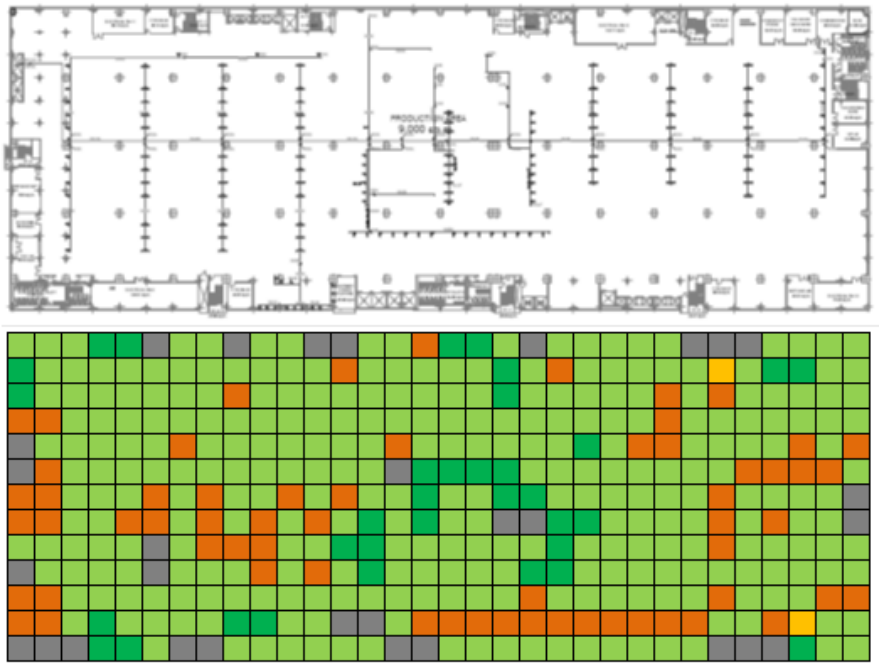
The areas investigated were divided into smaller sections of (6 x 6 square meters) and light cells were used to measure the luminance in the horizontal plane to the ground. The average values for each area were recorded.

1st Floor

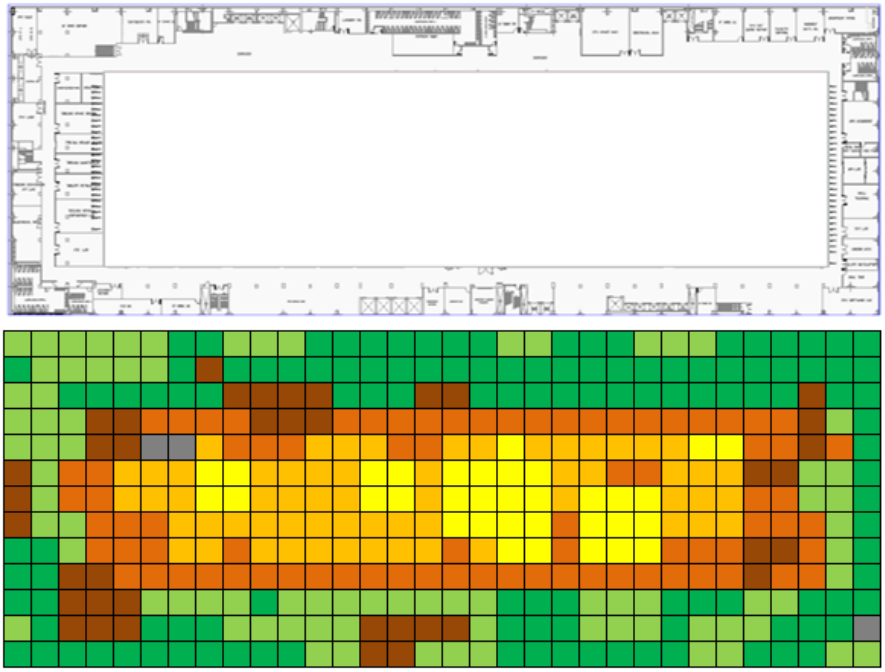




2nd Floor



3rd floor (Production Floor)



Step 2 Compare the luminance and activities of each area.
The luminance measurements were compared to the activities present in each area. It was determined that some areas had an excess amount of illumination as identified in the regulation standards for the administration and management of safety, health and environment related to heat, light and sound in 2549. This standard indicates that the factory is likely able to reduce the amount of unnecessary lighting.

Step 3 Disconnect unnecessary lamps

ชั้น	สถานที่	จำนวนหลอดไฟ (28 วัตต์)		จำนวนหลอดไฟ (36 วัตต์)	
		ก่อนปรับปรุง	หลังปรับปรุง	ก่อนปรับปรุง	หลังปรับปรุง
1	โรงอาหาร	276	**262**		
	ทางเดิน	367	**341**		
	สำนักงาน	222	**209**	50	50
	ห้องทดสอบ			273	**259**
	ห้องน้ำ	93	**88**		
	ห้องบรรจุภัณฑ์	2378	**2212**		
	ห้องปฏิบัติการ	40	40	116	116
	ห้องประชุม	42	42		
	ห้องพยาบาล	18	18		
	ห้องรับ-ส่งวัสดุ	139	**132**		
2	ไลน์ผลิตส่วนหลัง	78	78		
	ทางเดิน	70	70		
	สำนักงาน			18	18
	ห้อง IT	60	60		
	ห้องควบคุม	12	12		
	ห้องทดสอบ	4664	**4338**	48	48
	ห้องน้ำ	90	90		
	ห้องปฏิบัติการ			76	76
3	ห้องน้ำ	141	**134**		
	production service			9	9
	ไลน์ผลิตในห้องสะอาด1			3060	3060
	ไลน์ผลิตในห้องสะอาด2			4568	4568
	ไลน์ผลิตส่วนหลัง	98	98		
	ทางเดิน	675	675		
	สำนักงาน	18	18		
	ห้อง IT			135	135
	ห้องควบคุม	42	42	234	**222**
	ห้องซ่อมบำรุง			63	63
	ห้องซักรีด	12	12		
	ห้องทดสอบ	24	24		
	ห้องทดสอบชิ้นส่วน	76	76		
	ห้องปฏิบัติการ	24	24	102	102
	ห้องอุปกรณ์	24	24		

Reducing the unnecessary lighting can expect to produce savings of 625,398 baht per year. A reduction in the number of light bulbs will decrease the luminance but it will not be lowered below the standard incurring no impact on the performance of employees in each area.

The case study determined that a total of 590fluorescent light bulbs, 565 T5 Type bulbs and 25 T8 type bulbs can be removed, see below table.

T5 (28 Watt)			T8 (36 Watt)		
Before	After	Delta	Before	After	Delta
9683	9118	565	8752	8727	25

This measure can reduce the cost of energy by approximately 630,000 baht per year

4. Conclusion

This case study achieved the short term energy consumption and energy cost reduction goals through use of statistical techniques to evaluate the current state of industry energy consumption. The results of this study show that the hard drive industry has an opportunity to improve energy consumption and energy cost reduction.

The first measure is employee education; collaboration from employees is very important for a sustainable energy cost reduction. The second measure is efficiency improvement; the current largest consumer of energy is the HVAC (Heating, Ventilation and Air Conditioning) system. Implementing a new High-Efficiency Chiller system to replace the current HVAC system can reduce electrical costs by approximately 8.3Million baht/year. The third measure is to create a sequencing plan for chiller operation based on efficiency. This plan ensures the least efficient chillers are only used during high load demands, reducing the electrical consumption with no additional costs. The fourth measure is minimizing compressed air leaks; any leaked air is wasted and still costs the industry money. Reducing the amount of leaked air will save the industry approximately 2 hundred thousand baht per year. Finally, the fifth measure is evaluating the amount of required lighting and removing fluorescent lights in over lit areas. This measure can reduce energy costs by approximately 6.3 hundred thousand baht per year. The approach outlined in this paper can be used as a guideline for the electronics industry to evaluate the current state of energy consumption and set targets for energy reduction by choosing measures and maintaining good energy management.

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EXPLORING THE SUCCESS OF RURAL INFRASTRUCTURE DEVELOPMENT PROJECTS IN VIETNAM

Xuan Hung Pham

PhD Student – School of Global, Urban and Social Studies - RMIT University - Australia

Email: pxhung2002@yahoo.com or xuanhung.pham@rmit.edu.au

Mobile phone: +61- 452500606

ABSTRACTS

Rural infrastructure development (RID) projects have the potential to make a great contribution to rural economic growth and poverty reduction. It is therefore important to identify the factors that affect the success of these projects, taking into account different perceptions of what constitutes a successful RID project. However, little research has been done on this in the Vietnamese context. The purpose of this study is to explore perceptions of RID project success from different perspectives of stakeholders and to identify factors that influence the success of RID projects in context of Vietnam. Three recently completed RID projects were selected for a comparative case study. Based on 25 semi-structured interviews, a qualitative analysis approach was carried out to explore the perceptions of three key project stakeholders on success criteria and success factors. The study found that the perception of RID project success was different among three key stakeholders. While the project implementers emphasized on the success of the implementing phase, local beneficiaries paid more attention to the benefits and sustainability of infrastructure facilities. The project sponsors had wider views on RID project success criteria. This stakeholder judged RID project success not only in terms of effective usage of resource but also potential impacts of project on local communities. In term of success factors, the research indicated that on time payment of completed works, strong support from local government/mass organizations and active participation of local beneficiaries in monitoring and maintaining infrastructure facilities were important drivers for RID project success.

Keywords: Project success; success factors; rural infrastructure development project, Vietnam, project evaluation

1. Introduction

Infrastructure has been an important component of the national development strategy in Vietnam. Spending on infrastructure projects has remained approximately at 10 percent of Gross Domestic Product (GDP) - a very high level in comparison with international standards (Thanh & Dapice 2009). The development of rural infrastructure is the main concern of Vietnamese Government because nearly 70 percent of the total population is living in these areas (GSO 2011). During the last two decades, thousands of RID projects have been implemented in rural areas in Vietnam. These projects have generally had positive impacts in term of diversity of income sources, market access improvement and poverty reduction (Mu & Van De Walle 2007, 2011). However, the investigation of success criteria and success factors of these RID projects has not been adequately studied in previous research.

The aim of this study is to explore perceptions of RID project success from different stakeholder perspectives including project sponsors; project implementers and local beneficiaries. This study also identifies factors related to sponsor/government support and local participation that influence the success of RID projects. The remainder of the paper is structured as follows. In the next section, project success criteria and success factors within the project management literature are reviewed. It then describes the characteristics of three case studies and methods used in data collection and analysis. Next, empirical findings from case studies are presented before discussing the study results. The paper concludes with the implications and limitations of the study.

2. Literature review

2.1. Rural infrastructure development projects

RID projects in this study refer to physical public development projects. These projects are located in rural areas and specifically designed to support rural development and living activities in these areas (Pouliquen 2000). Table 1 shows key characteristic of RID projects.

Table 1: Key characteristics of RID projects in this study

Criteria	Characteristics
1. Project objectives	Main objectives of RID projects are poverty alleviation, improvement of living standards of local people in rural areas and capacity building of the local community.
2. Type of infrastructure	Physical public infrastructure facilities such as transport; energy; telecommunications; drinking water supply; schools and irrigation.
3. Funding	Projects are funded by government or international sponsors.
4. Implementing sites	Rural areas

Source: Author

2.2. Project success criteria

The study of project success is an area of great interest to project management practitioners and academic researchers. Traditional project success criteria known as the 'iron triangle' dimensions have focused on cost, time, and quality. These criteria have been widely used in previous research because they constitute economic and technical dimensions of project success and can be made objective, tangible, and measurable (Ika, LA 2009). In addition, they can be measured soon after project completion and used to evaluate a project manager's performance (Jugdev & Müller 2005). However, some commentators have pointed out that the iron triangle dimensions are too simplistic and inadequate in assessing project success. Shenhar and Levy (1997) have argued that triangle dimensions are not homogeneous dimensions. While meeting project resources constraints (time and cost) is one thing, meeting quality is another. In addition, these basic criteria usually reflect project performance in a narrow view, short-term and do not incorporate the views and objectives of all stakeholders (Bannerman 2008; Jugdev & Müller 2005; Shenhar et al. 2001).

Because of these limitations, other researchers have added new aspects to the notion of what would constitute a successful project. For example, Al-Tmeemy, Abdul-Rahman and Harun (2011) have developed a framework for judging the success of building projects. This framework consists of project management success (adherence to quality targets; adherence to schedule; adherence to budget); product success (customer satisfaction; functional requirements; technical specifications) and market success (revenue and profit; market share; reputation; competitive advantage).

In term of infrastructure development projects, Prokopy (2005) defined the success of rural water supply project in terms of five criteria: customer satisfaction; tariff payment; equal access; time saving and belief in the system. The weakness of these success criteria, however, is that they only measure the success of the operational phase rather than project success as a whole. In a later study, Wenjuan and Lei (2011) suggested a conceptual model for measuring project success in the public sector through the project lifecycle. This model includes three dimensions: construction success (project management success), operational success (perceived value of public users and government satisfaction with the results) and the multi-value successful standard (efficiency, equity, participation and sustainability). These authors have made significant contributions to clarify the success criteria of infrastructure development projects; however, they failed to reflect the perception of different stakeholders about criteria for judging project success.

A project has a range of stakeholder groups. Different stakeholders have different interests and judge project success according to different criteria (Baccarini 1999; Chan, Scott & Lam 2002). For example, the project manager and project teams who are engaged in day-to-day project execution may focus on the success of the project process (Rad 2003). Therefore, they see a project was successful when it has been finished on time, within budget, and to specifications. Project users are likely to concentrate on the impacts of project outputs. Project sponsors may be concerned with the survival of their project or the activity it was intended to support (Bannerman 2008). As a result, the criteria used to evaluate project success are based on stakeholders' particular expectations of the project (Jiang, Klein & Discenza 2002). Project success becomes a subjective evaluation from a person's perspective rather than an objective description based on independent criteria (Bartis & Mitev 2008).

In conclusion, project success is a complex concept for which it is impossible to use single-point indicators to measure success. Project success should not only be measured by time, cost, and quality but also on success after delivery. In addition, project success depends largely on the perceptions of stakeholders. In other words, each stakeholder in one project has their view point of success depending on their need and how well these needs are satisfied by the project.

2.3. Project success factors

Lim and Mohamed (1999) defined a factor as "any circumstance, fact, or influence which contributes to a result" and further described factors for project success as "influential forces which either facilitate or impede project success". Depending on the type of projects, success factors have been identified and listed in a variety of ways. For example, Chan, Scott and Chan (2004), undertook a thorough review of papers published in seven major management journals to develop a conceptual model of critical success factors for construction projects. In this model, project success factors were divided into five groups: project – related factors (e.g. type of project; nature of project; project complexity); human - related factors (e.g. team leader experience, organizing skills, and coordinating skills); project management action (e.g. communication system, feedback capabilities, and planning efforts); project procedures (procurement method, tendering method); and external environment. Tabish and Jha (2011) employed factor analysis to identify factors influencing the success of public infrastructure projects. The findings showed that factors influencing the success of public infrastructure projects could be classified into several groups: awareness of and compliance with rules and regulations; quality of pre-project planning and clarity in scope; effective partnering among project participants; and external monitoring and control. In the same vein, Wai et al. (2013) grouped success factors of infrastructure projects into six components: pre-construction factors; construction factors; post-construction factors; organisational factors; information management factors and change management factors.

The project sponsor is the person/group that provides the financial resources (PMI 2013). Support from project sponsors is an important factor for successful project. Pinto and Slevin (1987) found that sponsor's support, in the form of willingness to provide the necessary resources and the authority/power was one of the critical success factor, particularly in the planning and implementation stages of the project life cycle. Similarly, David (2008) used a survey to identify the role of sponsors on project success from perceptions of people working in both private and public sectors. The finding showed that project sponsorship efforts had a positive influence on the level of project success.

Rural infrastructure development project depend on public expenditure. Therefore, without continuous supports from government, there would be no expenditure approvals for project implementation (Jacobson & Choi 2008). Do and Tun (2008) argued that strong government commitment to project goals and objectives was an important factor for successful project.

Creighton (2005) defined community participation in development projects as a process through which stakeholders influence and share control over development initiatives. The objectives of community participation are the following: empowerment; building beneficiary capacity; increasing project effectiveness; improving project efficiency; and project cost sharing (Thwala 2010). Previous studies on rural infrastructure projects demonstrated that the beneficiaries' participation had significantly contributed to effectiveness of projects (Finsterbusch, Kurt & Van Wicklin 1987; Finsterbusch, K. & Van Wicklin 1989; Winters 2010). Thwala (2010), based on a case study of rural water supply project in South Africa, also found that when the community members were happy to be a part of the project management process, they were willing to pay for the clean water supply service and maintenance of water supply facilities. Therefore, community participation in the planning and management of developmental projects was crucial to their lasting success.

3. Research methodology

A qualitative research method with a case study approach has been chosen for this study. Qualitative approach is best used for research problems requiring depth of insight and understanding (Creswell 2012, p. 16). This research method allows researchers to retain the holistic and meaningful characteristics of real-life events (Yin 2009, p. 4). It also provides investigators with opportunities to capture the richness of the respondents' perception on success criteria and critical factors which contributing to achieve project success. In addition, RID projects in Vietnam are diversified and implemented in different context, thus, the multi-case study approach was appropriate because this approach could handle the complexity of the phenomena under the study (Eisenhardt 1989). Furthermore, the multiple case study approach uses replication logic to achieve methodological rigour (Yin 2009, p. 59) and triangulate evidence, data sources and research methods (Eisenhardt 1989). As result, the results from multiple case study may be more substantial (Yin 2009, p. 61).

The population consists of RID projects in Vietnam which were completed within 2 years, so that the information collected is not out-dated and respondents were able to recall relevant information related to the projects. Based on the recently completed RID projects which were obtained from Departments of Investment and Planning in Quang Binh, Quang Tri and Thua Thien Hue provinces, three RID projects were purposely selected to provide a diverse sample in terms of level of perceived success, project locations and project sponsors. The case study sites were also restricted to sites where the project participants were also willing to participate in the study and archival data were available. Based on the criteria stated above, two generally acknowledged to be successful projects (the inter - commune road project in Thua Thien Hue province (*coded as case A);* the clean water supply project in Quang Binh province (*coded as case B*) and one generally acknowledged to be unsuccessful project - the irrigation project in Quang Tri province (*coded as case C*) were investigated for the purpose of triangulation. A summary of the three projects is given in **Table 2**.

The data collection methods for the case studies included direct archival research, observation, and interviews (Yin 2009). The archival research included project feasibility study reports, contract documents, work programs, progress reports and project evaluation reports collected from the relevant project management offices and project sponsors. Direct observation was adopted in this study by visiting the rural communities where RID projects were implemented and visually inspecting the current state of the infrastructure.

The main data for this study came from the semi-structured interviews. Twenty-five key participants from three key project stakeholders (project sponsors, project implementers and local beneficiaries) were selected for interviews. Interviews were conducted with open-ended questions because this type of question allows interviewees greater freedom to share their experience and knowledge, and the interviewer has the opportunity to ask further questions in response to the respondent's replies (Bryman 2012).

Table 2: Profiles of three investigated RID project cases

Characteristic	Case A	Case B	Case C
1. Project type	Inter - commune road project	Clean water supply project	Irrigation project
2. Location	Quang Dien district, Thua Thien Hue province (coastal area)	Le Thuy district, Quang Binh province (plain area)	Dakrong district, Quang Tri province (mountain area)
3. Project goal	To enhance economic activities, reduce the poverty rate and improve the ability to access public services such as education and health for 34,100 people in three communes in Quang Dien district	Supply adequate and safe water for 1,365 households in 4 villages in An Thuy commune (Loc Ha, Loc An, Thach Ban and Tan Le)	To attain food self-sufficiency for people in Ba Long and Hai Phuc communes through sustainable small scale irrigation development
4. Project sponsor	International agencies (ADB and Agence Française de Développement (AFD))	Le thuy District Government	Quang Tri Province Government
5. Project cost	8,047 million VND (USD 502,000)	5,649 million VND (USD 353,000)	8,878 million VND (USD 554,875)
6. Implementing time	1/2011 – 10/2011 (10 months)	10/2008 – 8/2010 (11 months)	11/2010 – 12/2011 (14 months)
7. Number of beneficiaries	34,100 people in three communes: Quang An, Quang Thanh and Huong Phong	5,535 people in four villages in An Thuy commune	80 farmers in two communes: Ba Long and Hai Phuc

4. Findings

4.1. Stakeholders' views on the RID project success

Project stakeholders refer as "an individual, group, or organization who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project" (PMI 2013, p. 30). RID projects usually involve many layers of stakeholders with varied interests. However, according to Do and Tun (2008), there are three key stakeholders in RID projects including project sponsors; project implementers and local beneficiaries. Project sponsors pay for but do not directly use the project outcomes. Project implementers are responsible for the implementation of the RID projects. Project beneficiaries benefit from the project outputs but usually do not directly pay for the project, although they might contribute in important ways to it. In this study, we focused on investigation the success of RID projects from the perspective of these three key stakeholders.

Selection of a RID project that was relevant to both local communities' needs and the sponsor's priority was the first criteria for judging the success or failure of a RID project. Responses from interviewees in three stakeholders groups shared the common view that the selection of the intervention which could solve the most difficult problem for the local development was important success criteria. For example, interviewed local respondents in case A stated that the project was successful because the building of the inter– commune road met *"the desire of most people in our commune"* [Local beneficiary-case A]. This view was also supported by a respondent from the project sponsor:

> *"The first criterion we considered for the success of this project was whether it is really necessary for local development or not"* [Project sponsor-case A]

However, there were some differences among key stakeholders on other success criteria. While respondents from project sponsor and project implementer groups emphasized the importance of project to local development plan and sponsor's priority as success criteria, local beneficiaries were not interested in these criteria. The following excerpts serve to illustrate the views of project's implementers and sponsor:

> *"The priority of the sponsor was to reduce poverty and improve likelihood of the poor in coastal areas in central provinces through building inter-commune roads ...I think that, this project met the sponsor's priority".* [Project manager – case A]
>
> *"….the project objectives were in line with the An Thuy commune development strategy in the period from 2010 to 2015*". [Project sponsor -Case B]

Three RID project selected for this study were implemented in the poor areas where there were many problems needed to be addressed in order to enhance the social and economic development of local communities. Therefore, the selection of right projects that could addressed the main obstacles of communities was the main concern of all key stakeholders.

Project efficiency criteria relates to three traditional dimensions of project success (time, cost and quality). In term of project quality, respondents from all three project stakeholder groups had similar views that the quality of construction was a critical criterion to judge the success or failure of the RID project because it influenced the efficiency of resource usage and stability of project impacts. However, there were different perceptions among stakeholders in term of project cost criteria. For example, while interviewed project implementers and sponsors expressed that their projects were judged to be successful because they were completed within budget, local beneficiaries explained their view on project success in term of their cost for using the project's service:

> "*It depends on the location but the average cost for establishment of the pine system in our village was VND 500.000* (equal to $25). *This cost was cheaper than the cost of digging a well and I think that it is acceptable for most household in our village*" [local beneficiary – Case B]

Table 3: Stakeholders' views on RID project success criteria

Success criteria	Project sponsors			Project implementers			Project beneficiaries		
	Case A	*Case B*	*Case C*	*Case A*	*Case B*	*Case C*	*Case A*	*Case B*	*Case C*
Right project									
1. Addressing relevant needs of local communities	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Contributing to/in line with the local development strategy	✓	✓			✓				
3. Meet sponsor priorities			✓	✓					
Project efficiency									
4. Project activities were finished on time	✓	✓	×	✓	✓	×			
5. Project resource was used as planned (on budget)	✓	✓	×	✓	✓	×			
6. Quality of construction work	✓		✓	✓	×	✓	✓	×	×
7. Cost of using service was acceptable/affordable								✓	
8. Users were satisfied with service quality supplied			✓		✓			✓	×
Project impacts									
9. Positive impacts on local household's income			✓				✓		✓
10. Reducing cost of households	✓				✓		✓	✓	
11. Positive impacts on local security (e.g. travelling safer; disease reduces; food security)	✓	✓	✓				✓	✓	✓
12. Increasing opportunities for local people (e.g. expanding business activities; education)	✓						✓		
Local capacity impacts									
13. Improving local capacity				✓			✓		
14. Enhancing local ownership and operation capacity		✓	×		✓				×
Sustainability									
15.A.Sustainability of project benefits							✓		
16. Infrastructure facilities was likely operated for long-term		✓	×					×	×

✓= Good; × = Poor

Project impacts refer to positive and negative effects produced by the project (Chianca 2008). From the local beneficiaries' perspective, the satisfaction of economic benefits was considered as important criteria for RID project success. Interviewed local people perceived that due to the implementation of these RID projects, households' costs (e.g. cost of water usage; production cost) were reduced. Moreover, local people could have more opportunities to earn money from selling agricultural products with better price. The following local beneficiaries' comments illustrate this:

> "*At present, the price of clean water is 5.000 VND per a cube meter. My family uses 12 cube meter per month for basic demand and I have to pay VND 60,000 [*equal to $3/per month*]. This cost is cheaper than for cost of electricity I paid for getting the same amount of water from the well*" [Local beneficiary - Case B]

"I used to sell my agricultural products for mid-trader with lower market price. Now, due to easier travelling, I bring it to Tay Ba market and sell with better price" [Local beneficiary - Case A]

Sharing the similar positive views on benefits of project outputs, interviewed project sponsors stated that:

" ..Before the road was upgraded, farmers in these communes used the small boat for rice transportation from the field to their house. With wider road, they replaced the boat by motorbikes or vans. It was not easy to measure how much time they could save but I think that the transportation time was significantly reduced" [Project sponsor – Case A]

"Obviously, water users can save a lot of time when water was directly supplied to their home" [Project sponsor – Case B]

In term of social impacts, responses from project sponsors and local beneficiaries in three cases also stressed the positive impacts on local security (e.g. safer travelling; reduced disease; food security). The following statements showed perceptions of local beneficiaries and project sponsor on social impacts:

" … Before the project, it was very dangerous for walkers and cyclist when travelling the same lane with cars and motorbikes because the road wide was only three meter. Now, it is safer due to having more space for walkers and cyclists" [Local beneficiary - Case A]

"In the past, people in my village often got red eyes especially in the summer, but now it is better" [Local beneficiary - Case B]

"Before the project we could have only one rice crop in spring season due to lack of water. The other season, we grew maize or soybean. After the project, we grew rice in both seasons because there was more water available. The change of production structure improved food security in our community" [Local beneficiary - Case C]

"Thanks to building the inter-commune road, residents (in three communes) *were easier to travel to Sia town* (Quang Dien district centre) *and not afraid of isolation during flood period"* [Project sponsor - Case A]

Building local capacity and enhancing local ownership of infrastructure facilities were perceived as success criteria of these RID projects from the perspectives of all three stakeholders. According to local people interviewees in case A, the implementation of the project improved local capacity in managing similar RID projects. When local beneficiaries participated in the project, they learned how to identify the necessary infrastructure intervention, and monitor the quality of construction works. Local beneficiaries expressed their perception of the impacts of the project in terms of enhancing local capacity and local ownership of infrastructure facilities as following:

"During the participation in community meeting and project monitoring, I had opportunity to learn and share my experiences with other people. Therefore, I feel more confident in managing similar projects" [Local beneficiary - Case A]

"In my opinion, when water users actively participated and had contribution [labour, money] *to the building of water system, they were more responsible in managing the water system. For example, if water users found the water is lost* [due to the broken pine], *they reported directly to the An Thuy Electrical and Water Co-Operative for repairing"*. [Local beneficiary - Case B]

Interviewees from project implementers also shared the idea on the impacts of the project on local capacity building through maintaining infrastructure facilities. As commented by a project manager:

"When the project was completed, the road was transferred to local community for maintaining. With this way, I think that, it enhances the community capacity in maintaining infrastructure schemes" [Project manager – case A]

Sustainability, according to Chianca (2008) refers to the continuation of benefits from a project after major development assistance has been completed. As direct users of infrastructure facilities, local beneficiaries were interested in the long-term impacts of project outputs and they perceived that the sustainability of project was an important criterion for assessing the success of a RID

project. For example, respondents in case A believed that with current well management by local community, the road has continuously created long-term positive impacts on local people. However, local beneficiaries in case B and case C were concerned about the long-term operation of infrastructure facilities. An interviewee in case B stated that:

> *"Water providing to the system come from a big well at Loc Thuong village. During last years, water reserve from this well tends to be reduced. I think that it may influence the sustainability of the system in a few coming years"* [Local beneficiary - Case B]

Overall, respondents from three groups of project stakeholders have different focuses on success criteria. While project implementers were more concerned about the success of the project during implementation phase, local beneficiaries were more interested in quality of construction works, social and economic impacts of project on local beneficiaries and the sustainability of infrastructure facilities. Project sponsors have wider view on the success of RID project. This stakeholder was interested in both project implementation success and impacts on local economy. The reason for this differences were that project implementers judged the success of the RID projects at the time of construction completion. On the other hand, local beneficiaries assessed the success of the RID project during the operational phase.

4.2. Project success factors

Three case studies revealed several factors that affected the RID project success. In this paper, we focuses on factors related to sponsor/government supports and community participation that exist in context of RID projects in Vietnam.

On time payment of completed works

As a public infrastructure project, funding for RID projects in three cases came from government sponsor or international agencies. Therefore, the availability of financial resource was a critical factor that made it possible for the projects to be completed ahead schedule. A project manager in case A explained the reason for good performance in his project:

> *"Our project was funded by two international parties, due to the financial resource for this project was always available as plan, contractors were paid based on the completion of works"* [Project manager – Case A]

In case C, on the other hand, because the payment for completed works was delayed and financial ability of project contractor was weak, project activities were implemented depend largely on payments from the project sponsor. According to the contract agreement, the contractor was received 30% of total project when the contract was signed and the rest of project cost was paid based on completed works. However, because this payment was no paid as plan, project activities was implemented as plan. The main reason for delayed payments of completed works was that the payment system of project sponsor was complex. Response from the project contractor indicated that in order to get payment, contractor had to submit relevant documents to both the Dakrong district management office and the Quang Tri Department of Investment and Planning for approvals. It often took from three to four weeks to process this payment.

The funding for project was not only influenced the performance during construction phase but also impacted on project sustainability. For instance, in case C, the delay of financial disbursement significantly affected the performance and sustainability of the irrigation system. The interviewed local beneficiary said that:

> *"Funding for operation and maintenance the irrigation system came from the Dakrong district government. However, this funding usually was not provided as requirement for repairing the canal. Therefore, the performance of irrigation system is poor and unsustainable"* [Local beneficiary - Case C]

The availability of financial resource was a necessary condition for project success. However, on-time payment to the contractors was a more important factor for the success of the RID projects.

Strong coordination and effective supports from the local community government

The coordination between local community governments, project team members and project sponsor was important for the success of studied RID projects. Because of strong coordination among project managers, project sponsor and local government all problems rising during project implementation were solved in properly and timely. An interviewed project manager stated that:

"We have monthly meeting with district officers and chairman of three communes. We listened to them on current problems relating to the project and discussed to find appropriate approach to solve these issues" [Project manager – case A]

In addition, financial support from the local community government could enhance the ability to achieve project objectives. For instance, in order to encourage local people using the clean water from the new system, the An Thuy people committee (in case B) provided a financial subsidy of VND 500 thousand (equal to $25) for households who early registered for clean water system. As result, nearly 90% of households in Loc An and Thach Ban villages registered for using clean water in the first three months of operational phase.

Strong support from local mass organizations

Woman union, youth union and farmer union are three key mass organizations in rural communities in Vietnam. These organizations were established to enhance the relationships among members in the communes. The supports from mass organization leaders played an important role in order to achieve the commitment from local people. In case A and case B, mass organizations engaged in the project since the initial phase. During the community meetings, the leaders of these mass organizations played the role as facilitators to encourage participants raising their problems and prioritization. A project manager in case A commented the benefits of these mass organization supports:

"Support from local mass organizations enhanced the trust of local people in project participation" [Project manager – case A]

The important role of mass organizations was not only to influence the performance in implementation phase but also in operational phase of the RID projects. In case A, when the project was completed, the road was assigned to these mass organizations for maintaining. Therefore, sustainability of project outputs depended largely on the effective operation of these organizations.

On the other hand, the participation of mass organization in case C was limited because "top-down approach" was applied in this project. The leaders of farmer organizations in two target communes were not informed about the project and the participation of farmers were limited. One local respondent explained the reasons why the project did not achieve its objective:

"The water was not enough for rice production especially during the summer season. The cause of this problem was that the selection of water source was wrong. We [farmers] *were not involved in the project during designing the irrigation system. They* [technical designer] *ignored local knowledge"* [Local beneficiary - Case C]

High commitment of local beneficiaries in financial contribution and land sharing:

The implementation of many RID projects in Vietnam often requires the land for construction of infrastructure facilities. Land acquisition was considered as one of the risk that had significantly influenced on the success of RID projects. According to response from project team member in case A, land acquisition in this project was earlier than plan because most local beneficiaries who were influenced by the project perceived benefits of building the road and they were willing to give their land for project implementation. In case C, in contrast, due to local beneficiaries were not happy with land compensation, they did not give the land for building the irrigation system, as result, the construction activities were delayed.

The commitment of local beneficiaries in financial contribution significantly influenced the effectiveness and sustainability of the infrastructure facility. In order to connect to the clean water system, water users in case B had to pay from $25 to $35 for pipe connection and monthly water usage. The evaluation project report showed that due to most water users in four villages were accepted and willing to pay these costs, funding was often sufficient for the operation of clean water system in long-term. In addition, the contribution of local beneficiary had positively associated with project ownership; as a result, the commune could manage and control their water supply scheme properly. One project manager said that:

"In order to connect to the water system, water users have to sign an agreement with An Thuy Electrical and Water Co-Operative on the ownership of the assets and responsibility for maintaining the system. As result, water users actively participate to maintain the water system and pay water fee" [Project manager – case B]

Active participation of local beneficiaries in designing infrastructure, monitoring construction activities and maintaining of infrastructure facilities:

Responses from interviewees showed that local beneficiaries were closely involved in projects during construction phase in the successful projects (case A and case B), while this process was not sufficient in case C. According to response from a local beneficiary in case A, meetings at community gave him the opportunities to share experiences and knowledge during designing the road. In addition, when local beneficiaries had the authority to select the project; reviewed the project design and made suggestions and corrections, consultants understood better the local beneficiaries' requirements and helped ensure that the project met local needs. Moreover, with regular monitoring and feedbacks from local beneficiaries (members of the Commune Supervision Board) during road construction period the quality of construction works was as expected. A project manager stated that:

> "*We leave our contact number at construction site; therefore, local people can report directly any problems happening during road construction….so, we can monitor project activities regularly*" [Project manager – case A]

Monitoring the performance of the contractor regularly was a very important part of local participation. Local people respondent said that experienced contractors were not enough for project success, contractor's monitor was more important. He claimed that:

> "*During project implementation, if the project was not enough monitored* [by local people], *the quality of project works was not as expected*" [C2B2]

Similarly, respondents in case B explained the high quality of project outcomes for two reasons. One was the close inspection by local people. Two, as the consultants and contractors knew that all local people would be checking on them, they were also more thorough in their inspections.

On the other hand, in case C, the quality of construction works was poor. This was because the local people were not actively and able to monitor the construction activities. According to the respondent from the community leader, the participation of local people in monitoring construction activities was limited. As results, most construction activities in case C were supervised by their own project team members. The poor quality of project outcomes showed that self-supervision by project team were not effective.

Local participation in maintaining infrastructure facilities was a crucial element for project sustainability. In case B, when the project was finished, project outcomes were transferred to the An Thuy Electrical and Water Co-operative (an organization established by the AnThuy People Committee) for maintaining and the local people have took the final decision on important aspects of operation of the project. Therefore, the operation of project outputs were more sustainable.

To sum up, the findings from interviews showed that continuous monitoring the project's work progress and active participation in maintaining the infrastructure facilities would provide significant contributions for achieving project success.

5. Discussion:

5.1. Stakeholders' perception of RID project success

The stakeholder perceptions of RID project success are closely linked to the values that are held by stakeholders. Due to the complex relationship among project stakeholders in RID project, the success perspectives among these stakeholders is more diverse (Do & Tun 2008; Ika, Diallo & Thuillier 2012).

The case studies provide clear evidence that different stakeholder groups had different sets of success criteria. The project implementers consist of project managers, team members and contractors were directly responsible for delivering the outputs of the RID projects. The attention of this stakeholder group was directed at the production of RID project outputs. In other words they concerned mainly on performance of implementation phase of the RID projects (cost, time and quality of project) and their perspective on project success was short-sighted. These findings are in line with the literature review where Bryde and Robinson (2005) and Rad (2003) claimed that project implementers often put more emphasis on minimizing project cost and duration. Nonetheless, this stakeholder was also interested in what extent the project addressed relevant needs of local communities; meet sponsor's priority and enhance local capacity. On the other hand, local

beneficiaries who received the benefits of the RID projects were more interested with the impacts of infrastructure facilities. Results from three case studies indicated that local beneficiaries paid more attention on the economic and social benefits of project outputs on their life such as increasing agricultural productivity; reducing of production cost and improving local security. However, as direct users of project outputs, local beneficiaries were interested in the quality of construction and the sustainability of infrastructure facilities in long-term.

In comparison to above two stakeholders, the project sponsors assessed the project success of RID projects from a broader perspective. They not only place emphasised on the relevance and project efficiency but also concerned public utilities of infrastructure facilities. In other word, the project sponsors seen the success of RID projects from strategic view.

5.2. Success factors related to sponsor/government supports and community participation

Previous studies showed that the support from project sponsors, in the form of willingness to provide the necessary resources was one of the critical success factors, particularly in the planning and implementation stages of the project. The financial difficulties of project sponsor during implementation phase was a top cause of delay in many infrastructure projects (Frimpong & Oluwoye 2003; Nguyen & Ogunlana 2004). The finding from case studies showed that in the context of RID practice in Vietnam, because the financial ability of most contractors was weak, the support from project sponsors in term of on time payment for completed works more significantly influenced the project performance. Moreover, findings from case studies also indicated that the support from local community government (land acquisition, financial subsidy) could improve the likelihood of RID project success. When the local governments have strong commitment to project goals and objectives, the project is more likely successful (Do & Tun 2008).

Notably, the findings from these case studies showed that mass organizations such as woman unions, youth unions and farmer unions played important role to enhance the likelihood of RID project success. The supports of these organizations could improve the effective participation of local people in selecting of appropriate infrastructure scheme and monitoring construction activities at site. In operational phase, the participation of mass organizations in maintaining infrastructure facilities could influenced positively long-term impacts and sustainability of project outputs.

The degree of local beneficiaries' involvement in RID projects is positively influence the implementation performance and project output satisfaction of projects (Thwala 2010; Winters 2010). The findings from these case studies showed that the strong commitment and willing to participation of local beneficiaries (e.g. financial contribution, land sharing) significantly affected RID project success. In addition, when the community members were happy to be a part of the project management process (active participation in monitoring construction activities and maintenance of infrastructure facilities), the performance of RID project outputs were better and more sustainable.

6. Conclusion and limitation of the study

The purpose of this study is to explore perceptions of different stakeholders on RID project success and identify factors related to project sponsor/government supports and local beneficiary participation using multiple case studies. The case studies confirm that RID project success was interpreted differently from different stakeholder perspectives based on their interests, values and concerns. The project implementers concerned mainly on performance of implementation phase of the RID projects with short-term success. Local beneficiaries were more interested with the utilities and impacts of infrastructure facilities on their life. Project sponsors had a wider view on the success of RID project, emphasizing the success of RID projects in terms of both project implementation success and impacts on local economy. In term of success factors, this study indicated that on time payment of completed works; strong supports from local government/mass organizations; active participation of local beneficiaries in monitoring and maintaining infrastructure facilities were important drivers for RID project success.

Because this research used a case study approach with a small sample size, the findings are not simply generalizable. The success criteria and success factors are suitable within respective projects due to the fact that each project has its own unique conditions. The study has highlighted some

important issues, and it is recommended that a future study involving more cases of other types of RID projects be conducted to test the broader applicability of these findings.

7. Biography

Xuan Hung, PHAM is a PhD candidature at RMIT University – Australia. Before studying at RMIT University, he worked as lecturer and researcher at Hue College of Economic, Hue University, Vietnam. He also worked as project consultant for several rural development projects in Vietnam.

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Influence of Electrodialysis Operation Parameters on TDS Removal

Kanungnuch Keawsupsak[a], Siriporn Larpkiattaworn[a]*, Julaluk Pannoi[a],
Chutima Eamchotchawalit[a], Romchat Rattanaudom[b], Gamgarn Thummadetsak[b]

[a] Material Innovation Department, Thailand Institute of Scientific and Technological Research, 35 M.3 Khlong Luang, Pathumthani, 12120, Thailand (E-mail: *kanungnuch@tistr.or.th)*
[b] PTT Research and Technology Institute, 71 M.2 Phaholyothin Rd., Sanubtub, Wangnoi, Ayuttaya, 13170, Thailand.

*Corresponding author
Siriporn Larpkiattaworn, Material Innovation Department, Thailand Institute of Scientific and Technological Research, 35 M.3 Khlong Luang, Pathumthani, 12120, Thailand (E-mail: *siriporn@tistr.or.th)*

Abstract

In this study, the electrodialysis was performed to concentrate or dilute the salt solution for treatment of total dissolved solid (TDS) in wastewater. The operation parameters of feed temperature (15, 25 and 35°C), feed concentration (4,000, 20,000 and 50,000 mg/L) and the applied current (0.3, 0.6 and 0.9A) of system were studied. It was found that the operation temperature at 25°C resulted in the highest efficiency of NaCl separation for 50,000 mg/L feed solution at 0.9 A. By increasing concentration of feed, the initial flow rate decreased rapidly within 30 min, after that it was stable with time. The transport of Na^+ and Cl^- ions from dilute side to concentrate side increased as the high salt concentration of feed which is due to the high content of sodium and chloride ions. The increase of applied current enhanced the voltage, flow rate and the separation efficiency. After the treatment of NaCl solution of 50,000 ppm for 60 min, the TDS reduced 8.9, 16.6, 23.8 and 33.6% as the applied current of 0.3, 0.5, 0.6 and 0.9 A, respectively. Electrodialysis at the current of 0.9 A and the temperature of 25°C for 140 min, the TDS in diluted solution was less than 3,000 mg/L, thus the process could be applied for the wastewater treatment. On the other side, the treatment produced the concentrated NaCl solution of 163,779 mg/L which could be recycle to use in the process.

Keywords: Electrodialysis; Sodium chloride; Wastewater; Total dissolved solid

1. Introduction

Generally, wastewater form industries consisting of suspended and dissolved organic as well as inorganic compositions that need to be treated in order to meet the standards and/or expectations set for the effluent quality. Removal of suspended organic and inorganic solids has been achieved through electroflocculation [1], carbonaceous adsorbent [2], bioreactors [3], ultrafiltration [4], and nanofiltration [5]. After the removal of organic and suspension, the high amounts of dissolve solids that are commonly known as total dissolved solids (TDS) has been treated. There are several other treatment methods such as chemical precipitation, adsorption, electrophoresis, softening and reverse osmosis, which are possible applied to remove dissolved solids from wastewater [6]. Nowadays, Electrodialysis (ED) is one of the interesting treatment methods for TDS. It is considered as a clean technology because it presents several advantages over traditional processes, such as: no requirement of adding reagents; runs continuously and generated no polluting waste in the environment [7, 8]. In previous researches, ED was reported for removal TDS such as Ca^{2+} , Mg^{2+} , K^{+} , Na^{+} , SO_4^{2-}, HCO_3^{-} and Cl^{-} in wastewater [6-10]. In this research, the variation of operation parameters such as feed temperature, feed concentration and applied current have been studied over the effect on flow rate and TDS removal.

2. Experimental

The ED apparatus used in this experiment is a batch type dialysis unit. The model is DW-Lab, SELEMION^{TM} (Japan). It stacks with 5 cell pairs of AMV (strongly basic anion-exchange) and CMV (strongly basic cation-exchange) membranes having an effective area of 0.003 m^2/piece. The properties of ion exchange membranes were presented in Table 1. DC power is provided by a rectifier which have maximum voltage of 18 V and maximum current of 3 A. The electrodes are titanium plate coated with iridium for the anode and the cathode is stainless steel. A 30,000 ppm Na_2SO_4 was used as an electrolyte solution.The 400 mL of NaCl solution was used as feed with various concentrations. The schematic diagram of the ED cell is shown in Fig. 1. During the treatment, the flow rate, conductivity, TDS and NaCl content were measured in both diluted side and concentrated side.

Table 1 Properties of cation and anion membranes for the electrodialysis.

Properties	Cation membrane	Anion membrane
Thickness (mm)	0.12	0.12
Counterion	Na^{+}	Cl^{-}
Strength (kPa)	200	200
Resistant 0.5 mol/L NaCl (25ºC) ($\Omega\,cm^2$)	3.0	2.8
Resistant 0.5 mol/L $NaNO_3$ (25ºC) ($\Omega\,cm^2$)	2.9	3.3
Resistant 0.25 mol/L Na_2SO_4 (25ºC) ($\Omega\,cm^2$)	0.7	5.5
Resistant 0.5 mol/L HCl (25ºC) ($\Omega\,cm^2$)	0.3	2.5
Resistant 0.25 mol/L H_2SO_4 (25ºC) ($\Omega\,cm^2$)	0.3	7.0
Transport number (t-Na^{+})	>0.96	-
Transport number (t-Cl^{-})	-	>0.96

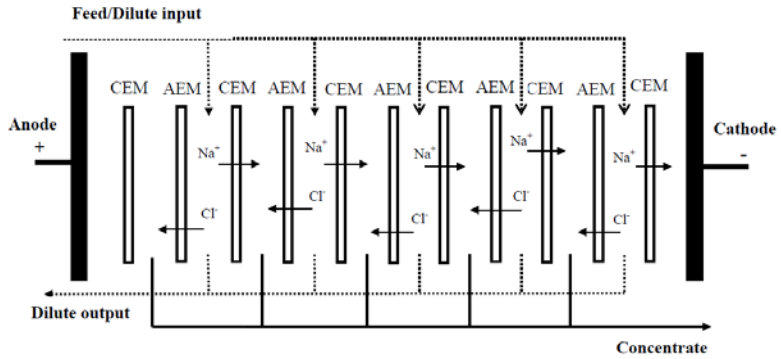


Fig.1 Schematic diagram of electrodialysis operation.

3. Results and discussion

The effects of operating parameters on TDS removal were investigated in this work. The feed temperature (15, 25 and 35°C), feed concentration (4,000, 20,000 and 50,000 mg/L) and applied current (0.3, 0.5, 0.6 and 0.9 A) were varied during the experiments.

The feed NaCl concentration of 50,000 mg/L and the applied current of 0.9A were used to study the effect of feed temperature. Fig. 2 show the flow rate operating at higher temperature of 25°C and 35°C is faster than that at 15°C. The flow rate is rather stable at all three temperatures over the working time 140 min. The conductivity and TDS concentration in the dilute side were given in Fig.3. Both conductivity and TDS of the NaCl feed solution performed the same trend of graph that the values decrease with time increase. At the initial operation, TDS removal performance at all operating temperatures are nearly. After the feed solution was diluted for over an hour, the dilution rate at 25°C and 35°C performed faster than that at 15°C. This is because the ionization of NaCl solution to sodium cation (Na^+) and chloride anion (Cl^-) is usually increased as the temperature increase [9]. Therefore, high ion concentration would affect the increase of flow and dilution rate at the same condition.

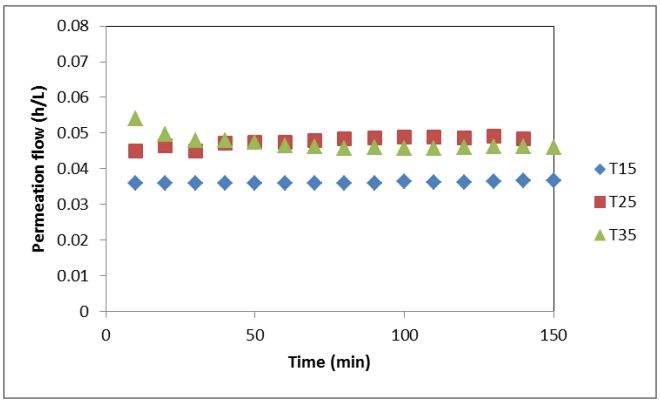
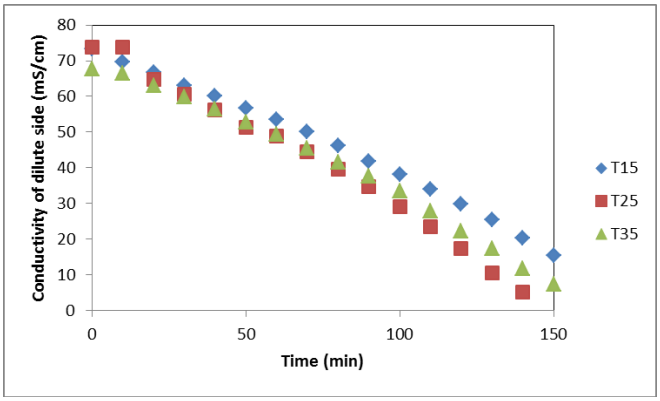
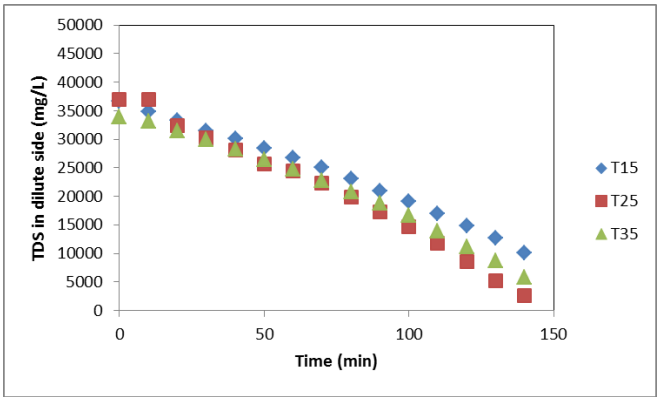


Fig. 2 The flow rate of NaCl removal from the dilute side to concentrate side at various feed temperature.



(a)



(b)

Fig. 3 The effect of temperature on: (a) conditivity and (b) TDS of solution in the diluted solution.

Fig. 5-6 show the effect of NaCl concentration on permeation flow, conductivity and TDS concentration. In case of high concentration of NaCl feed solution (20,000 and 50,000 mg/L), the stability of permeation flow was observed after 30 min operated time while the flow of low concentration feed solution (4000 mg/L) continue to decrease with time. The dilution rate of TDS in high NaCl concentration is faster than that in the low concentration solution for the operating time of 60 min.

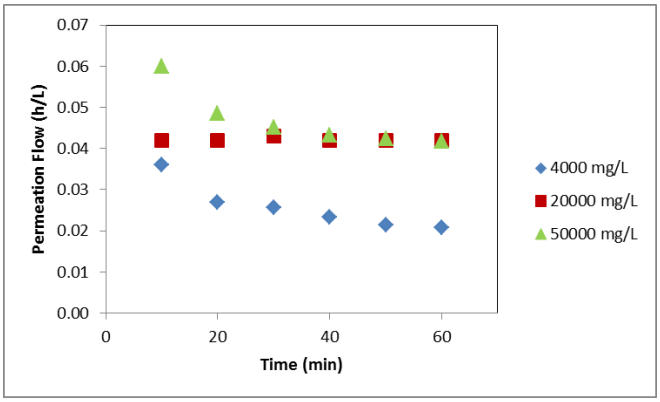
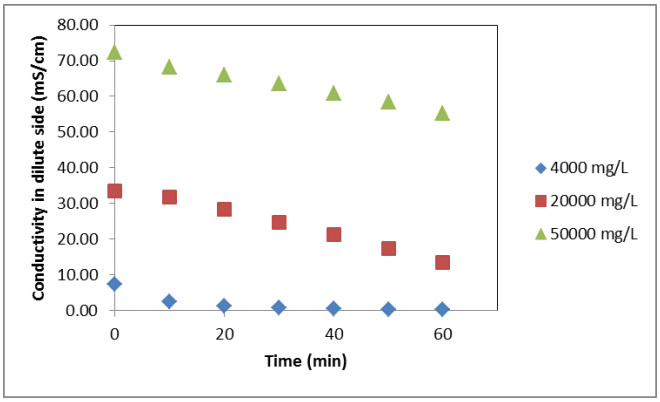
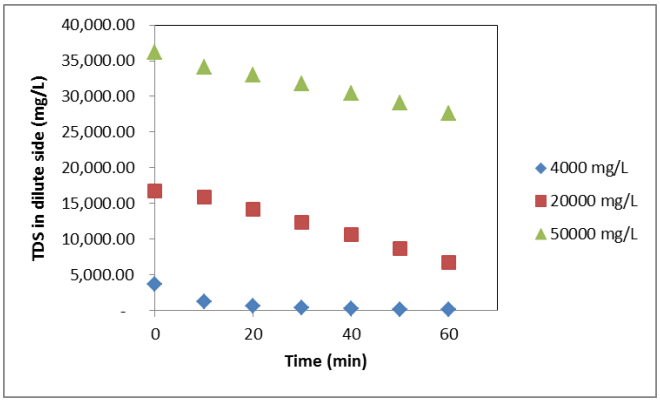


Fig. 4 The flow rate of NaCl removal from the dilute side to concentrate side with various feed concentration.



(a)

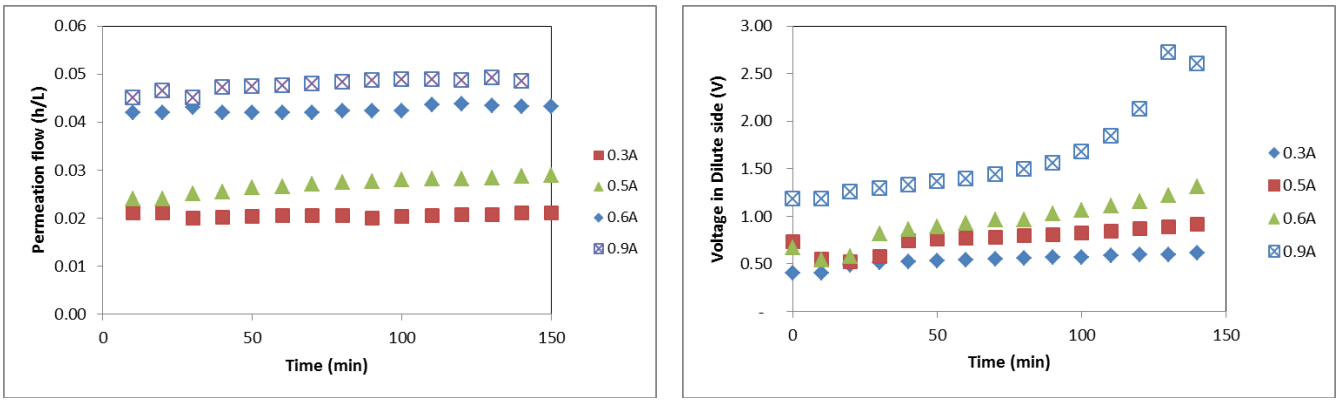


(b)

Fig. 5The effect of concentration on: (a) conditivity and (b) TDS of solution in the diluted solution.

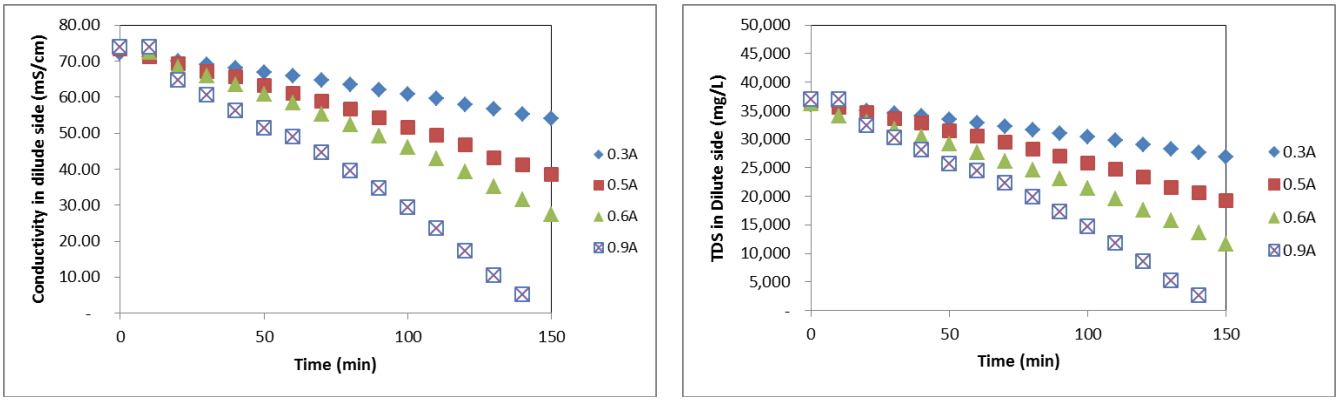
The effect of applied current on the TDS was studied by using a NaCl concentration of 50,000 mg/L as a feed. The permeation flow and voltage of the system increased with applying higher current as shown in Fig. 7 and Fig. 8, respectively. This result can be explained by the fact that increasing current reduced the resistance and augmented the voltage. The decrease of resistance in the system caused the high permeate flow and reduced conductivity as well as TDS in the diluted side.

After ED treatment of 50,000 mg/L NaCl solution with 0.9 A at 25°C for 140 min, the residual TDS was less than 3,000 mg/L as given in Fig. 8. According to wastewater standards for quality control, TDS concentration is determined less than 3,000 mg/L. Therefore, the ED process has potential to remove high concentration NaCl in wastewater. For the concentrate side, the NaCl concentration of 163,779 mg/L was produced which can be reused in the process; in case of wastewater compose of only one single dissolve solids.



(a) (b)

Fig. 6 The effect of applied current on: (a) The permeate flow rate and (b) the voltage in dilue side.



(a) (b)

Fig. 7 The effect of applied current on: (a) the conditivity and (b) TDS concentration of solution in the diluted side.

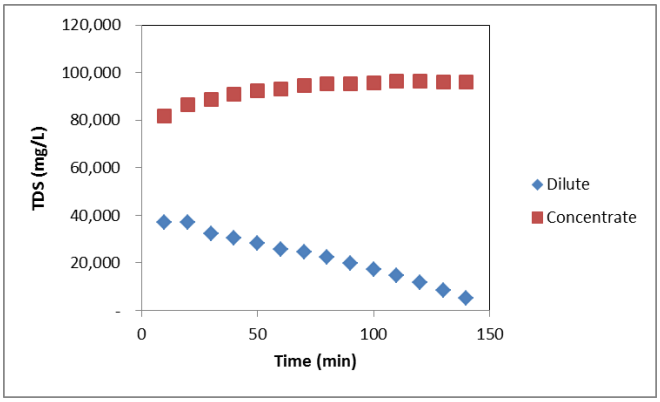


Fig.8 Compare TDS concentration as the treated TDS of 36,000 mg/L the applied current of 0.9A and the temperature of 25°C for 140 min.

4. Conclusions

Feed temperature, feed concentration and applied current are the parameters to control the TDS removal efficiency of ED process for NaCl solution. The increase of each parameter led to high ion transportation, and then high permeation flow. Therefore, the dilute side results in low NaCl content while the concentrate side produce high NaCl content. In this work, TDS was removed from high concentration of NaCl solution (50,000 mg/L) to less than 3,000 mg/L which the ED system could be applied for high salt wastewater treatment.

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Issues in Environmental Sustainability:

Policy and Politics of Preserving Kanawa Forest in Gombe State, Nigeria

By

Rahmatu Buba
Department of Political Science
Faculty of Arts and Social Sciences
Gombe State University
Gombe-Nigeria
Email address: ramatububa05@yahoo.com

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Forests in Nigeria are recognized as a formidable base sustaining the economy of the Country and the livelihood of the rural populace. The forests provide the raw materials for both primary and secondary industries while generating employment for a sizeable number of the people. However, one of the key resources in Nigeria that is increasing fast in its non-sustainability status is the forest. In order to address this issue, this study examines the threats to Kanawa forest which has for some time now been seriously neglected and has received little or no improvement in terms of investment and management. The paper examines the many reasons that account for the threat to the sustainability of the Kanawa forest. The Kanawa forest is common-pool resource that is of great concern in this era of major ecological challenge. The study indicated that the Kanawa forest in Gombe state has not been able to meet the criteria for sustainable forest management because of its open-access compounded by the problem of ineffective policy and governance by the state government to preserve and manage the forest. The paper suggested that an effective policy for preserving Kanawa forest should be put in place to ensure sustainable utilization and management of the forest resource. The paper also recommends that the forest should be revitalize to an ecotourism centre as local people around Kwadon and Kanawa can get income and employment from ecotourism, and are less likely to destroy the natural resources through unsustainable exploitation.

INTRODUCTION:

Forests perform a number of vital natural services, they provide important products for human use and consumption, and they also provide valuable ecosystem services. Among

other things they conserve biodiversity, moderate regional climates, prevent erosion, store carbon and nutrients, and provide recreational opportunities (Richard, 2008). They provide a number of vital goods, too, such as lumber, the raw material for making paper, fodder for domestic animals, fibers, gums, latex, fruit, berries, nuts, and fuel for cooking and heating. They also provide employment for 60 million people. In spite of these values, the world's forests are under threat not simply because of their exploitation, but rather, their total destruction. According to the 2005 Global Forest Resources Assessment from the U.N Food and Agricultural Organization (FAO) forest continue to be cleared at an alarming rate, about 13 million per year in 2005, most of which in the developing countries.

In Nigeria however, one vital resource that is increasing fast in its non-sustainability status is the forest. Nigeria was once covered by extensive vegetation varying from humid tropical forests in the south to savanna grasslands in the north. A great percentage of this luxurious vegetation has been removed in the course of various human activities. Exploitation of these forest resources often causes deforestation, which has been a big problem in this Nation. Nigeria destroys 600,00 ha of forest annually whereas only 25,000ha are replenished (FAO,1983). Presently, forest reserves cover about 10% of the National territory, mostly of the savanna woodland type. The southern rain forest, the source of the country's timber resources, covers only 2% of the total land area of Nigeria. It is being depleted at an annual rate of 3.5% per year. This implies deforestation on a large scale. The persistent decline in the National forest has been a source of concern to the Federal Government. In order to arrest this situation, the Government has embarked on several programmes and projects on reforestation and afforestation. However, despite the fact that Forest Management in Nigeria is mostly limited to government programmes all the forest reserves, which form the bulk of the nation's productive forest, are under the management of the States or Local Governments. The forest outside forest reserves (free areas), are not put under any form of systematic management and one of such forestry is the Kanawa forest in Gombe State.

For centuries Kanawa forest provides the people living around Kwadon Local Government Area of Gombe State a source of their livelihood. From the forest they get fuel for cooking, fodder for their cattle, fruit, timber for building their houses and medicinal herbs for curing diseases e.t.c. The forest helps in maintaining the flow of perennial springs, in bringing rain, in keeping the soil and water conserved, in preventing landslides, thereby giving protection from this natural calamity. It helps regulate watershed management so as to maintain the fertility of the soil, control droughts and floods, and preserve wildlife. The forest has for some time now been seriously neglected and has received little or no improvement in terms of investment and management.

THEORETICAL FRAMEWORK

This study is situated within the Tragedy of the Commons theory. The concept of the Tragedy of the Commons is extremely important for understanding the degradation of our environment. The concept was clearly expressed for the first time by Garrett Hardin in his now famous article in Science in 1968, which is "widely accepted as a fundamental contribution to ecology, population theory, economics and political science." Hardin: University of California Santa Barbara.

The idea that something that no one owns is badly treated goes back at least as far as Aristotle, wrote that "what is common to many is taken least care of, for all men greater regard for what is their own for what they possess in common with others (Durant, 1939). As described by Harding set of problems in which there is an open access to the commons, but

where there is no regulating authority (or there is one, but is ineffective) and no functioning community. Exploitation then becomes a free-for-all in which profit is the only motive. Written at a time when environmental problems were still relatively new on the political agenda, Garrett Hardin's metaphor of the 'tragedy of the commons' helped to shape our collective understanding of, and response to, the ecological crisis. Hardin used this simple parable, borrowed from a pamphlet written in 1833, to argue that the only way to avert the "tragedy of freedom in the commons" was through strong state intervention, i.e. "mutual coercion, mutually agreed upon" (Hardin 1968: 1244-47). This echo of Hobbes' call for a Leviathan – a sovereign state capable of imposing order on the 'state of nature' – struck a sympathetic chord with policy-makers and analysts, resulting in the construction of an elaborate administrative state to undertake environmental regulation (Paehlke and Torgerson 1990).

The fact that forests are treated as open-access resources can be explained in terms of market failure (Pearce and Brown, 1994). First, local market failure means that those who convert forest land take the benefits from doing so (for example, timber revenues) but do not have to pay the costs (loss of subsistence livelihoods, soil erosion, loss of biodiversity, loss of future revenues from timber if forests do not regenerate). Second, governments either fail to address this market failure (and make those who gain from forest conversion pay the costs), or offer perverse incentives (for example, failing to tax or regulate logging companies, or allowing inefficient logging practices that encourage wastage), so that the economic balance is pushed towards forest conversion. These problems are exacerbated by poor governance, with inefficiency and corruption tending to favour the short-term profits of large corporations at the expense of forests (and very often the people who live in them).

In many developing countries, the state has taken authority to regulate the use of forest land, timber and other forest products, but lacks the authority and power to implement them. It is therefore, obvious that there is something wrong with the vital resources management of Kanawa forest located at Eastern part of Gombe State, deforestation which has taken place due to exploitation of trees for timber, resin, medicinal herbs, etc., over-grazing by animals, have become evident in the forest resulting to tragedy of the commons. Therefore, an improvement in the policies in preserving Kanawa forest is necessary if sustainable development is to be achieved, as effective management can only come from effective policies.

IDENTIFICATION OF THE RELEVANT LITERATURE

The environmental literature has been especially significant for improving our understanding of environmental policy and politics in protecting the earth's environment. It is also pushing forward the theoretical literature on global governance as international relations scholars explore ways to embrace a more holistic analysis of global environmental management. There is however, a large and growing body of literature on environmental problems and policies towards a sustainable environment.

All over the world, particularly in developing and third world countries, human dimension aspect of natural resources management has become a serious cause of concern. According to Whitmore and Sayer (1992), human impact on the global environment has increased greatly in recent centuries, and especially during the last 50 years. Our responsibility for and attitude to the environment is one such problem which is now the subject of intense debate. Theorists and policy analysts often discuss environmental issues in the context of a more general understanding of what human beings are and how they are

related to each other and to the rest of the world (O' neil, 1993). The negative impact of human activities and their consequences on the environment are intricately connected and are complex. This is because they manifest in unsustainable development practices that endanger the very base upon which the human and non-human existence depends. It is however, political because it involves the making of policy decisions about the best way to achieve certain objectives that affect the present citizenry and future generations (Oyesola, 2008).

Ian Johnson noted correctly that it is mandatory for the present generation to "protect the natural environment for future generations" (Johnson, 1999). For this to be effective, each and everyone have to be involved. It is the onus of every citizen to protect the environment, it is the devoir of the government authorities and statesmen to protect the environment, it is the duty of all politicians to make the protection of the environment their priority, it is equally the job of Non-Profit Organizations (NGO), national and international involved in Environmental Management to mitigate the destruction the Environment is suffering from. These changes will threaten acquired rights and established interests, which means that widespread public support from citizens is a necessary condition for a permanent, structural solution to the environmental crisis (Achterberg 1993). The promotion of sustainable development needs to take into consideration such reactions from the grassroots. Certainly bottom-up involvement could help in attaining more successful sustainable development agendas. Furthermore, the promotion of sustainable development must be participatory if it is to succeed.

It is the policy option of all governments today to "stop the massacre" of the environment (Seis, 1998).Similarly, Planning for a sustainable future also involves an increased role for government, an increase which may not necessarily be accepted at grassroots level. It therefore requires the construction of 'a shared public basis on which to ground the legitimacy of restrictions and corrections' if sustainable development policies are to be successfully implemented (Achterberg 1993). But participation is not just a means whereby pre-existing sustainable development policies can be legitimized. Increasingly, participation is seen as a necessary part of the formulation and implementation of policy.

KANAWA FOREST GIFT OF NATURE

Kanawa forest was established in 1940 by Gombe native Authority with an area of about 173.259 acres. Kanawa forest is located between latitude 10 17 N and 10 16 N found in Yamaltu Deba Local Government Area of Gombe State, about 10km away from Gombe metropolis on the Gombe-Biu road. The plantation is mainly cassia, palm, neam, mango, guava, banana trees. It also has a stream adjoined with ten natural spring water run in the plantation. The current uses of kanawa forest include irrigation work as a result of the availability of water in the forest reserve.

Because of the availability of water in the forest, the forest serves as a source of income for the youths around the Kwandon and Kanawa villages, as the youths engage in washing vehicles for motorists moving between the Gombe – Biu road. Travelers usually stop by the forest along the roadside to rest and enjoy the gift of nature. The temperature is moderate, with beautiful greenish vegetation.

The Kanawa forest can be regarded as a common pool resource. People of different category including native doctors searching for medicinal herbs go into the forest to fetch many products. Some of these products for instance fuel wood, mango, guava, banana e.t.c are taken to the Kwadon market for sale. Seedlings are also raised in the Kanawa forest. Initially, the seedlings were raised by the Gombe State government under the supervision of

Ministry of Forestry and Environment but later when the forest was abandoned, people started rising the seedlings for sale.

There is absolutely no doubt that the Kanawa forest is a gift of nature, but the activities around the forest including man-made destruction, improper use and handling have resulted in unsustainable use of the forest. The forest is supposed to be served as a tourist centre, where it will generate income to both the government and the surrounding community, but because of the failure from the government – under the supervision of the Ministry of Forestry and Environment and the Ministry of Tourism and Culture to regulate and protect the Kanawa forest resulted in abundant and mis-use of the forest reserve.

THREATS TO THE SUSTAINABILITY OF KANAWA FOREST

Major factors hindering the sustainability of the Kanawa forest were socio-economic, such as unclear tenure and property right, inefficient use of the resource, inadequate information about the forest, above all inadequate and effective policy and weaknesses in implementation of the forest management plan and enforcement of the forestry law. These factors have led to some impacts such as loss of revenue, economic insecurity and instability, loss of biological diversity, depletion of the forest resource and disempowerment of the rural communities.

Kanawa forest reserve witnessed a decline in size from 173.2sq acres in 1940 to 37.42 acres in 2012, representing 78.3 percent in decline. Factors responsible for the decline in the forest reserve include

a) Population growth and farming activities: The current population of Nigeria is put at 170 million. The population has therefore grown dramatically since the 1952/1953 census when it was 31.5 million. Gombe state in northern eastern Nigeria has an estimated population of 261,536. Population growth has put a lot of pressure on the kanawa forest as farming population seeks for more land for survival. As population increases, more houses built around the forest and therefore, resulted in the reduction of the forest size. Other buildings in the area are constructed for commercial purposes among which are filling stations.
b) Exploitation for firewood: the survival of rural dwellers and urban poor depends on finding enough firewood to cook meals. At present, fuel wood constitutes the main source of fuel for cooking by over 76% of the Nigerian population. UNDP figures for 1993 showed Nigeria consuming 262,783 metric tones. This factor prevents kanawa forest from recovering and this leads to degradation of the forest. Therefore overharvesting of fuel wood is one major factor contributing to the degradation of the Kanawa forest and if this is not controlled kanawa forest is at risk of extinction.
c) Overgrazing as a result of intrusion of cattle's in the forest makes it very difficult for young tress to regenerate and grow. This has led to 14% decline in the forest reserve. Overgrazing therefore, is a primary factor in the degradation of the Kanawa forest and is obvious this is as a result of negligence by the government.

THE POLITICS OF PRESERVATION: KANAWA FOREST

Nigeria is ranked 133rd out of 142 countries surveyed in environmental sustainability with an Environmental Sustainability Index (ESI) of 36.7 (CIESIN, 2002). This abysmal score underlines Nigeria's vulnerability to environmental risks and a lack of institutional capacity to respond quickly to the threats in a sustainable manner. Presently, the effective implementation of sustainable development plans generally depends on the ability of the electorate to elect a responsible government that will faithfully implement policies that

ensures the sustainability of the environment. However, Leadership at the national level is one key part of governance for sustainable development.

The institutions responsible for forest and biodiversity management at both the federal and state levels are coordinated through the National Council on Environment. The National Council on Environment is thus made up of the Federal Ministry of Environment and State Commissions of Environment. There is however, no single government agency solely devoted to biodiversity conservation in the country. The indiscriminate felling of trees has continued in virtually every part of the country.

However, enhancing the implementation of sustainable development in Nigeria will require the strengthening of law enforcement agencies to effectively combat corruption, increasing infrastructural development through the sincere and progressive implementation of policies and projects. In this regard, there is a need for a reduction of frequent and unpredictable changes in government administrative policies in order to create a stable and predictable policy and regulatory environment for the implementation of sustainable development. As such, the inclusion of measures to ensure the continuity of sustainable development policies is necessary. Thus, it is important to ensure that such policies are not jettisoned without due consultation with the citizenry. It is necessary that measures are taken towards empowering citizens to compel the government to fulfill such policies in view of available resources. To a great extent, the realization of sustainable development in Nigeria will depend on the state's balanced understanding of the complex nature of the intimate connections between socio-economic development and environmental issues and their implications to national progress, democratic stability, national security, and human life as well other fundamental freedoms. Thus, the state's pursuit of sustainable development greatly implies good governance.

Therefore, given the local nature of many of the challenges facing Kanawa forest sustainability, the Gombe state government has to play a role in protecting the forest from depletion. The Gombe state government and Yamaltu-Deba local government areas have the authority and power to do this. They also have the means to ensure that decisions are applied. The three most important means by which Gombe State government can influence sustainable development (for better or worse) are regulation, taxation and spending. And one important way of bringing back to life the Kanawa forest is to upgrade the forest reserve to an eco-tourist centre. Ecotourism can provide local communities with motivation to maintain and protect the forest and wildlife. When local people get income and employment from ecotourism, they are far less likely to destroy the natural resources through unsustainable exploitation.

CONCLUSION

Natural resources provide basic needs such as water, food and energy which individuals and societies need in order to survive and prosper. The growing degradation and scarcity of natural resources is a worrying issue. The need for the protection of environment becomes a necessity. In fact environment is a totality of human life; it means that it is sources of food, clothing, and shelter. However, because most forests in Nigeria are common pool resources the rate of afforestation continues to be far slower than the rate of exploitation. Therefore, there is need for the Nigerian government to avert overuse or misuse of the commons in ways that would deplete or degrade its resources. Effective policies must be put in place to ensure the sustainability of forestry in Nigeria.

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MUNICIPAL SOLID WASTE MANAGEMENT AND RAGPICKERS : A CASE STUDY OF NAGAON TOWN IN ASSAM, INDIA

Gajendra Mohan Dev Sarma[1] and Dr. M. C. Sarma[2]

1. Department of Geography, Raha College, Raha, Nagaon, Assam, India.

(Research Scholar, KKH State Open University, Guwahati, Assam, India)

2. Director, CIQA, KKH State Open University, Guwahati, Assam, India.

Abstract:

The conscious world is very sensitive today to the term 'environmental degradation' and municipal solid waste management (MSWM) is one of the urban environmental issues of serious concern. Reuse and recycling, among the principal means of waste minimization, inevitably deserve a special mention. In the hierarchy of the stakeholders in recycling processes of the non-biodegradable municipal wastes, ragpickers hold their place in the primary stratum. Unknowingly they play a vital role in MSWM in urban areas, particularly in recycling, though they perform it certainly either for their subsistence or pocket money. Despite being neglected and hated, not supported with proper training and protective wear like mask, gloves, boots etc., they seem to relentlessly perform their task. In the MSWM realm , the technical part is always stressed and the social issues seem to generally be ignored . The present case study aims at examining critically the role and status of ragpickers, one of the important social phenomena, in MSWM in Nagaon town in Assam, India. Both primary and secondary data have been used. For primary data, questionnaire and interview method have been employed, the sample size being 34 ragpicker children and women living in slum colonies in Nagaon town.

Keywords : municipal solid waste management, pollution, ragpickers, reuse, recycling, Nagaon town, Assam.

1. Introduction

Generation of solid waste has its root in the early days of human civilization. It was not regarded as a big problem those days because of low population and abundance of land. Wastes were disposed easily and insignificantly. There were times when degradable household wastes were dumped in homesteads for decomposition to naturally transform into bio-manure which, with traditional knowledge base, was used in agriculture for gaining an increasing production of crops. With the passage of time population increased, the process of urbanization combined with industrialization gathered a momentum and unsustainable landuse for habitation, trades and industries became intensive (Bhide and Sundaresan,2001). Disposal of solid waste started to stand as a big problem.

Urbanization, one of the significant by-products of the so-called developmental process, has been going on causing, firstly, the drastic expansion of existing urban areas, also coupled with the building up of new urban areas, and secondly, contributing to the exponential growth of urban population because of ceaseless migration from the rural and semi-urban areas. Augmentation in area and population both have resulted in the increase in the rate and quantity of municipal solid waste (MSW) generation in spatial and temporal dimensions. The urban dwellers have adopted the 'made easy' or 'use and throw' culture and plastic has entered the day- to-day urban life as an inevitable item starting from market to the kitchen. Urban lifestyle enriched with a comparatively high purchasing power, and the lack of community awareness of environmental issues can be enumerated as some of the significant reasons for huge generation of MSW. Naturally, municipal solid waste management (MSWM) arises as an unavoidable area of urban life.

In the MSWM domain, the technical side is always given prime importance while the social side seems generally to be ignored. Ragpickers have become an integral part of MSWM in any corner of urban India and this is a social dimension of the event.

2. Ragpickers

The Concise Oxford English Dictionary gives the meaning of 'ragpicker' as a person who collects and sells rags. The word 'ragpicker' is broadly used to denote the persons who pick some items from wastes and refuses. The words 'waste-picker', 'garbage combers', 'scavengers' are also often used to mean ragpicker, they are also known as 'Khattewala' in Delhi (Anand 2010).

3. Ragpickers' Status

Generally, ragpickers live in slum areas or colonies in cities and towns and they do not get access to education, health care, sanitation, and some basic amenities of civic life. Anand (2010) found in a study of 100 rackpickers in Delhi that majority of the waste pickers were living in slum settlement.

In the study done by Anand (2010), ragpickers were found not to have proper houses to live with better facilities, about 70 per cent of them lived in *Jhuggi-Jhupri*

areas, often 4/5 of them shared one *Jhuggi* , 60 per cent were having their own houses and the rest were living in rented houses paying Rs. 300-600 per month.

They are usually unorganized group of people, mostly children and women, engaged in collecting and selling of recyclable items from the heaps of garbage for their livlihood or pocket money. Mahadevia and Pathak (2008) found that most of the ragpickers in Hyderabad are teenage boys and children who earn their living through scavenging. According to Kehle et al.(2008), 'Ragpickers are usually women, members of the backward castes and children.'

In spite of playing a very significant role, the Ragpickers, who mostly are women and children, are neglected ones and not recognized within most of the MSWM systems (Kehle et al. 2008). They unknowingly perform a vital task of MSWM by segregating the dry wastes that go for recycling and reuse. They pick up from the



Fig. 1: Flow of Municipal Solid Waste Recycling

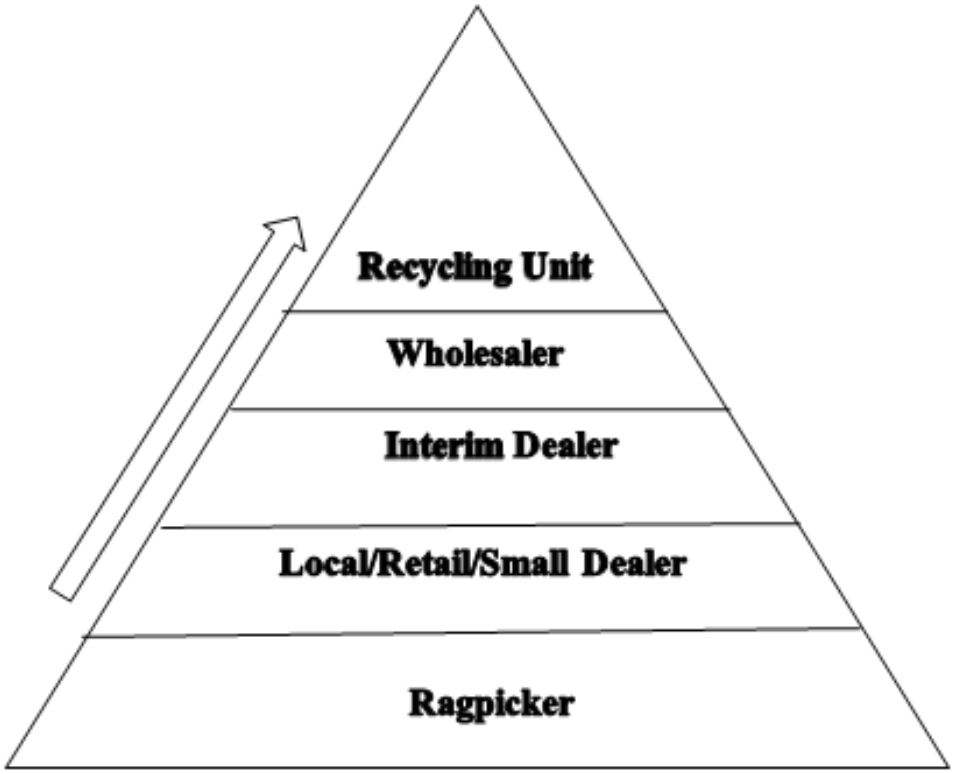


Fig. 2 : Hierarchy of Stakeholders in Recycling

garbage any saleable items and sale them to the local dealers, either to earn living or for pocket money. They are mostly migrants and temporarily settled in public lands. The local people do not prefer to involve themselves in ragpicking jobs in fear of losing dignity in society. 'Ragpicking is done more by migrants rather than locals, the reason being strong disapproval against waste picking and the fear of being ostracized by relatives' (COWI-Kadam, 2004).

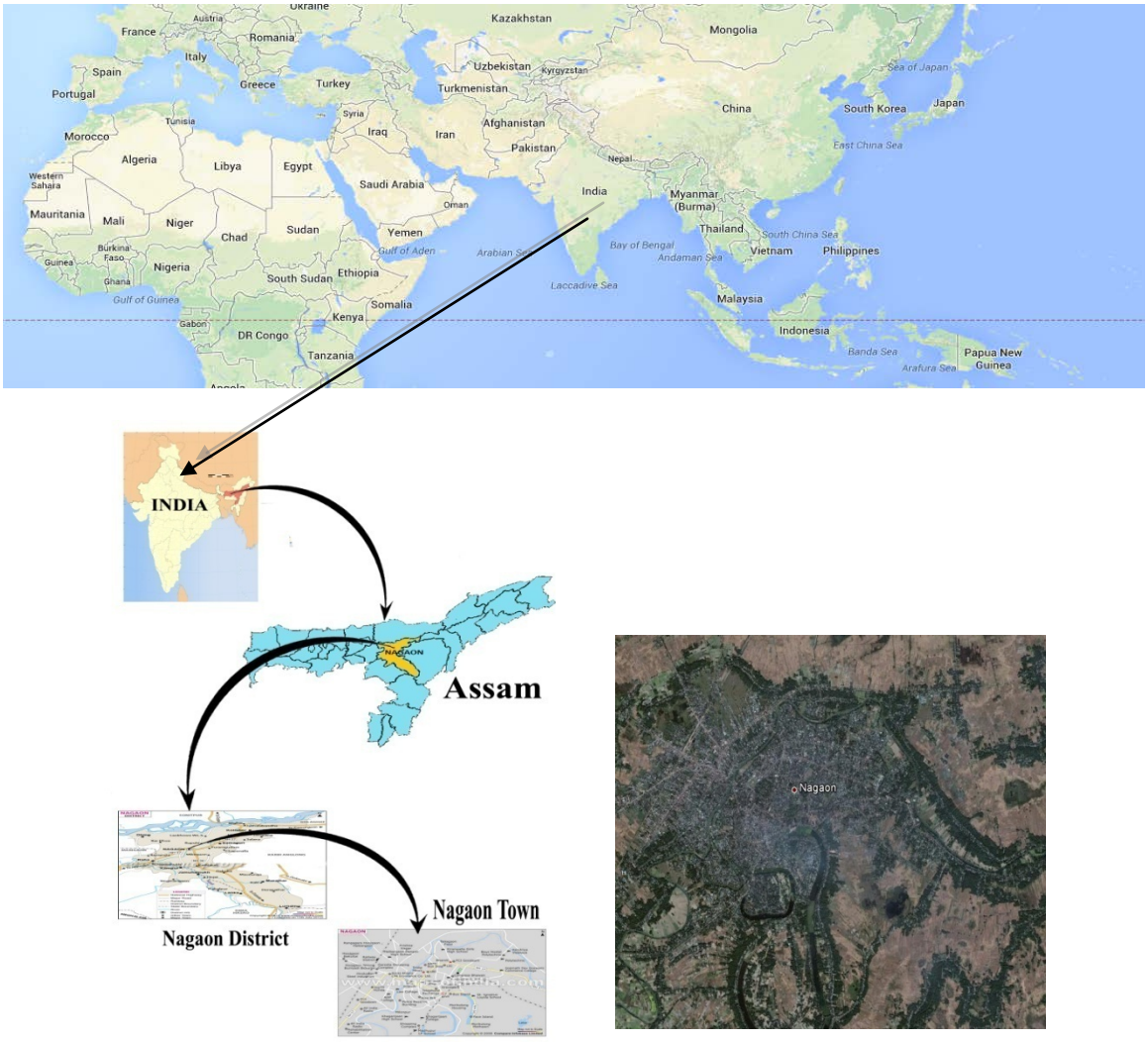
3. Negative role

Ragpickers have some negative impacts too. They scatter the wastes while rummaging through the garbage in search of saleable recyclables/reusables. This certainly creates problems in the civic atmosphere and the MSWM system as well. 'Besides the multitude of health problems that ragpickers face, the problem of scattered waste on streets makes for increased health risks to other members of society and becomes an expensive task to clean up afterwards. During the monsoon season, scattered waste easily clogs up open drains and sewers causing extensive flooding in the city.' (Kehle et al.,2008).

4. Ragpickers and MSWM in Nagaon Town

4.1 Study area

Nagaon town is the headquarter of Nagaon District located in the middle part of the Brahmaputra valley. It is a non-industrial town situated at an altitude of 61 metres above sea level. The latitudinal and longitudinal extension of the town can be considered to be from $26^0\ 20^/\ 14^{//}$ North (*Sensuwa*) to $26^0\ 22^/\ 05^{//}$ North (*Rangagora*) and from $92^0\ 40^/\ 02^{//}$ East (*Sensuwa*) to $92^0\ 42^/\ 56^{//}$ East (*Dimaruguri*). There is no such highlands within the periphery of Nagaon town and it is an alluvial plain, the soil is of sandy new alluvium. The Kolong, the major river (channel) in the town, passes meandering through the town and divides the into two halves, Haibargaon and Nagaon. Haibargaon slopes down toward the west and then to south while Nagaon slopes down towards the southeast and south and then towards the Kalang river.



Nagaon town Satellite Imagery

Fig. 3 : Location Maps of Nagaon Town

The climate of Nagaon town is characterized by a highly humid atmosphere, rainy summer with a plentiful rainfall. The winter is from December to February. This

is followed by the pre monsoon season of thunderstorms from March to May. The period from June to September is the southwest monsoon season, while October and November form the post monsoon season (Barooah,1978).

Nagaon town has an average rainfall of 1760 mm. per annum. Temperature in winter varies from a maximum of 24.8^{o} C to a minimum of 11.2^{o} C. In summer, temperature ranges from a maximum of 32.9^{o} C to a minimum of 25.5^{o} C, the average annual maximum and minimum temperature being 30.4 o C and 19.8^{o} C respectively.

Nagaon Municipal Board is the urban local body (ULB) functioning in the town. The ULB has an area of 9.22 square kilometer with 25,696 number of household having a population of 1,16,355 distributed in the total 26 municipal wards according to 2011 census. Combined with the outgrowths of the town, Nagaon town has a huge population of 1, 47,137 (2011 census) and it ranks as a class I town daily producing about 36 metric tonnes of MSW with a value of 0.30 kg/capita/day.

4.2 Methodology

This paper is an attempt to throw light on the role played by ragpickers in MSWM in Nagaon town, Assam. Questionnaire and interview method were employed for collection of primary data. A specific questionnaire was designed to highlight the required information as to the individual, family, social, and economic profiles of the ragpickers. A pilot survey was conducted with a view to omitting the unnecessary questions and adding some relevant ones. The sample size is 34 ragpicking children and women selected at random from 2 slum colonies in the town under study. Some of them were interviewed on the spot while working, i.e. while collecting rags. Field observation was also of great use to conceive a holistic idea on the status of the ragpickers working in the town.

4.3 Discussion, conclusion and recommendation

4.3.1 Habitation

All the ragpickers were found to be slum dwellers settled in government land such as along railway tracks, the bank of Kalang river etc. They live in a filthy and unhygienic condition in such areas where some basic amenities of civic life such as sanitation, pure drinking water, proper drainage, health care, education etc. are lacking. Their dwelling places usually are heavily crowded and void of open spaces.

4.3.2 House types

They were seen not living in a good house because they are poor enough to possess it. Their houses are huts, which are also familiar as *Jhupri*, made of jute bag/sac material, plastic bag material, cardboard, polythene sheet, plastics, bamboo, cheaper tins, thatch, leaves of coconut or date palms or banana etc. It may be said without any second thought that their houses are insecure.











Sex	Number	Percentage (%)

Fig. 4 : Common house types of the ragpickers

4.3.3 Age-sex

Out of 34 samples 20 are male (58.8 %) and 14 females (41.2%). Among the males, 11 (55% of the males) are children of the age up to 10 years ; 8 children (40% of the males) in the age group of 11-12 ; in the age group 13-16, there is only 1 (5% of the males) ; and there is none above the age of 16. This is not an welcome phenomenon. The females exhibit a bit different age structure. 2 girl children are of the age up to 10 years (14.2% of the females) ; 1 teenage girl (17 years) constitutes 7.1 % of the females ; in the 20-29 age group 3 women constitute 21.4 % of the females. Within the 30-39 age group lie 4 women forming 28.4 % of the females ; 3 women being 21.4 % of the total 14 females in the 40-49 age group ; and lastly, 1 woman in the age group 50 years and above constitutes 7.1 % of the total females.

The data unfold a unexpected truth which is a forbidden event and bears the unhealthy sign of under-14 child labour, the percentage being 61.76% (21 children out of

total 34).

Male	20	58.8
Female	14	41.2
Total	34	100

Table 1 : Share of sex

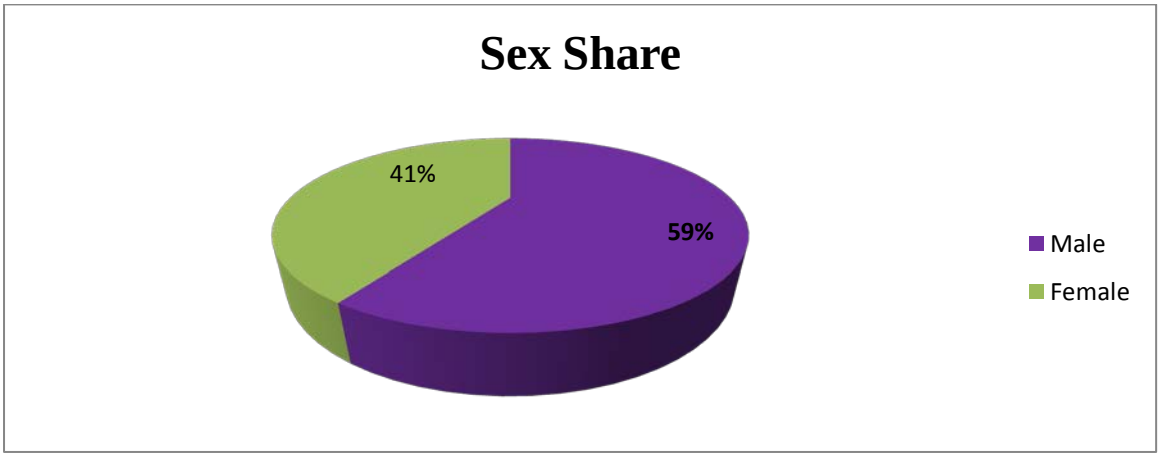


Fig. 5 : Sex share

Male Age group

Age (Year)	Percentage
Upto 10	55
11-12	40
13-16	5
Above 16	0

Table 2 : Male age group

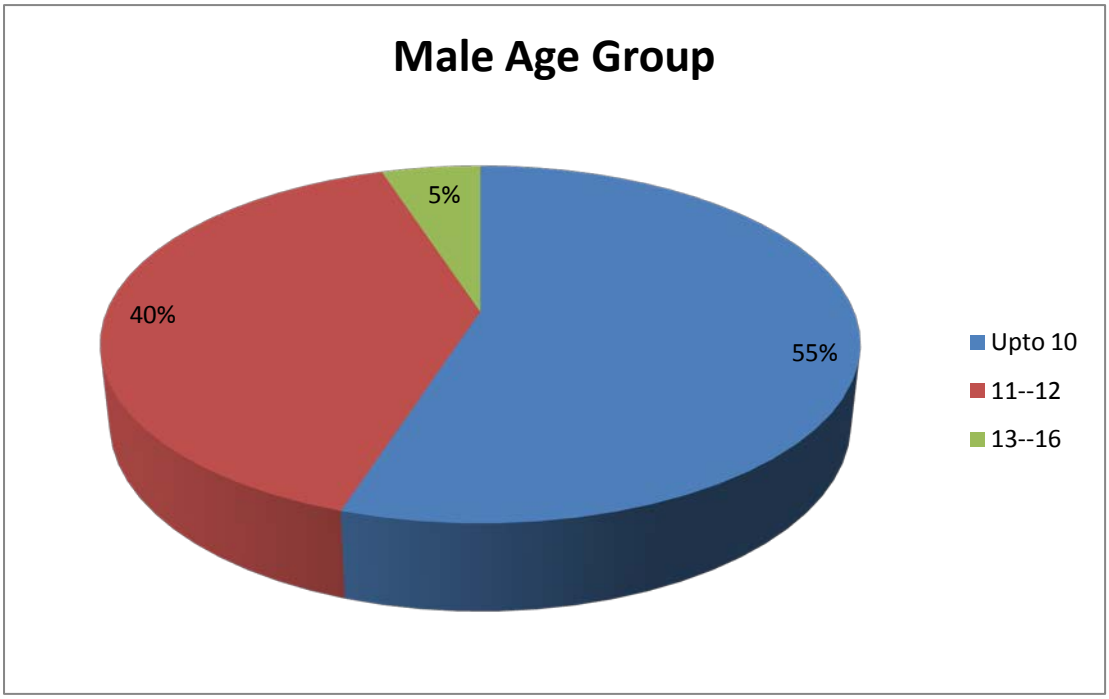


Fig. 6 : Male Age Group

Female Age group

Age (Year)	Percentage
Under 10	14.2
16-19	7
20-29	21.4
30-39	28.4
40-49	21.4
50 & above	7

Table 3 : Female Age group

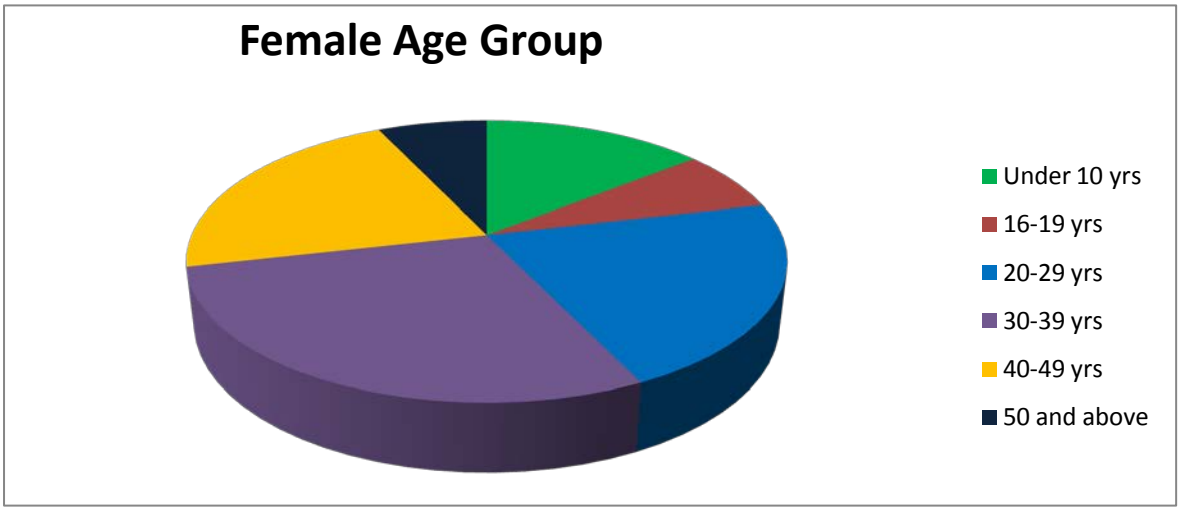


Fig. 7 : Female age group

4.3.4 Family size

About 90 per cent of the ragpickers have bigger family size with 6-10 members. Their uneducated parents, most probably with the expectation of achieving children's income, reproduce large number of children.

4.3.5 Economic condition

They deserve the 'very poor' label in the real sense of the terms. They are really having miserable economic condition, living in BPL families, the major suffering being malnutrition. They are compelled to involve themselves in the ragpicking job that requires no investment. The ragpicker children under study in the 8-12 year age group earn an amount of Rs. 30-60 daily excepting a 10-year and two 12-year boys with daily income of Rs. 100-150. A boy of 16 years of age earns a good income of Rs. 200 per day. But it is interesting to note that almost all of them do not have the good habit of saving and spend the hard-earned money for frivolous pleasure. In contrary, the female ragpickers utilize their income either by sending it for family needs like food items, clothing etc. or save it for positive purposes. 8 women out of total 14 within the age group 35-50 earn Rs. 100-120 per day. The rest from the age group 25-35 earn within the range of Rs. 60-80, while two girls of 17 year and 8 year earn Rs. 80 and Rs. 30 respectivly.

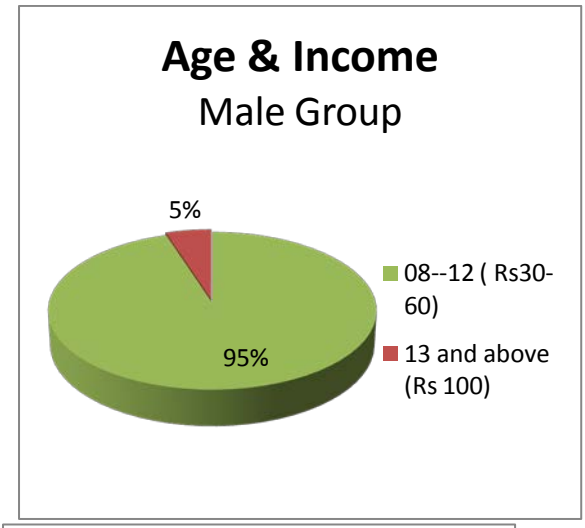
Age group (Years)	Average Income (INR)	percentage
8-12	30-60	95

13 & above	**100**	**5**

Table 4 : Male income profile

Age group (Years)	Average Income (INR)	percentage
8-17	30-80	1
25-35	60-80	42
35-50	100-120	57

Table 5 : Female Income group



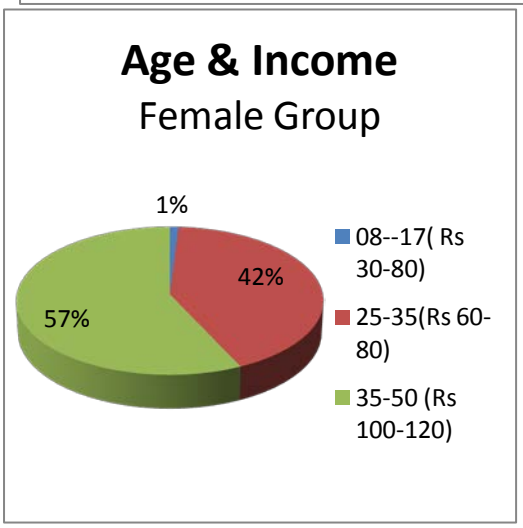


Fig. 8 : Age-Income graph of the male and female ragpickers

Ragpickers sell the plastic/cardboard/metal and different items items they collect from household/roadside/ garbage/ dump to the local dealers for the following prices. The following table shows the prices for different items :-

Item	**Price (INR) /Kg.**
Plastic	15
Cardboard	5
Polythene	10
Iron	20

Copper	300
Brass	220 -250
Hendulium (?)	70 -80

Table 6 : Per kg. price list of saleable items

Bottles and some containers are sold for different prices per piece as shown in table 7 :

Item	**Price (INR) /piece**
Biscuit tin	20
Beer bottle	2
Glass bottle (750 ml.)	1
Glass bottle (180 ml.)	0.5
Plastic bottle (2 Litr.)	1
Plastic bottle (1 Litr.)	.50

Table 7 : Per piece price list of saleable items

4.3.6 Education

The educational level of the ragpickers are very low, 20 out of 34 (about 59%) are illiterate, the rest 11 boys and 3 females can hardly sign their names in Assamese or Bangla, 55% and 28.5% being male literacy and female literacy rates respectively.

Literate / illiterate	**Percentage**
Male (literate)	32.35
Female (literate)	8.8
Total Illiterate	58.8

Table 8 : Literacy Rate

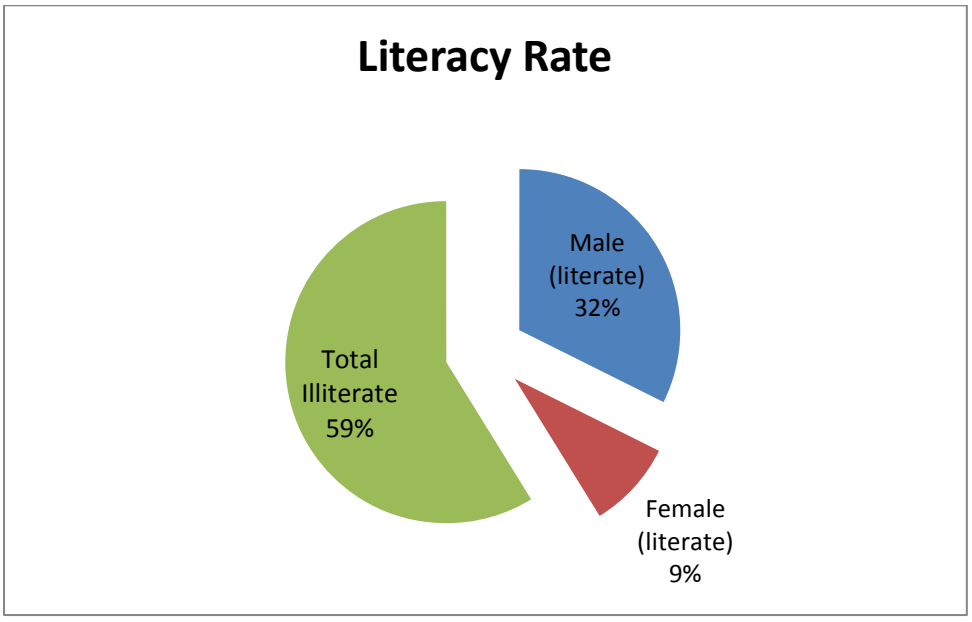


Fig.9 : Literacy Rate

Out of total 20 males and 14 females, 11 males and 12 females can hardly sign their names in Assamese or Bengali, 55 % and 28.5 % being literacy rates respectively for males and females.

Sex	Total Number	No. of literates	Literacy Percentage
Male	20	11	55
Female	14	4	28.5

Table 9 : Literacy percentage out of total male and female

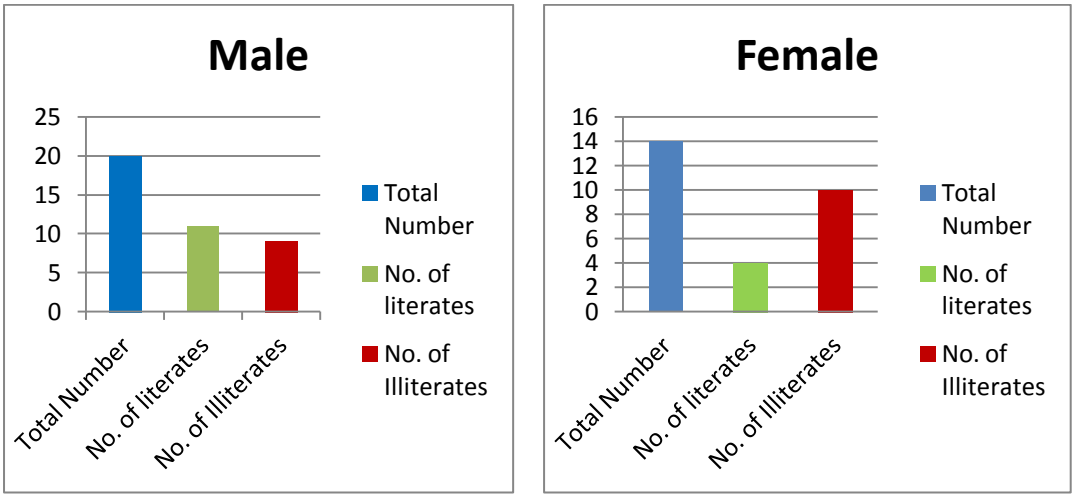


Fig. 10 : Literacy graph on total male and female

4.3.7 Social status

Social status of the Ragpickers seem to be kind of low level. They suffer from inferiority complex and shun exposure and publicity. The indigenous local people generally avoid the job of ragpicking in fear of losing social dignity in spite of its money making advantage.

4.3.8 Health

Most of the ragpickers were found to suffer from diseases like cough, fever, TB and various skin infections. They generally ignore their health problems and continue the ragpicking job until they are bedridden falling severely sick. As they, without any protective wears, work with the filthy, rotten and malodourous wastes, ragpickers are vulnerable to some diseases, often infectious ones. 'Direct handling of solid waste can result in various types of infectious and chronic diseases with the waste workers and the ragpickers being the most vulnerable.' (Raman and Sathia Narayanan, 2008).

4.3.9 Bad habits

Almost all the ragpicking boys reported that they were indulged in drug abuse in addition to sewing of tobacco. 11 boys reported to have three bad habits of either drugs taking, tobacco sewing and gambling or drugs taking, tobacco sewing and smoking. 6 boys were habituated in four bad habits, viz. drugs taking, smoking, tobacco sewing, and gambling. 5 women were reported to sew tobacco. These squalid activities make them vulnerable to various diseases.

4.3.10 Role in MSWM

The ragpicking children and women unknowingly play a vital role in municipal solid waste management. Reuse and recycling are two important components of MSWM. In Nagaon town, the urban local body (ULB) has not gone for any incineration or composting plant so far and, therefore, reuse and recycling of the dry MSW are very significant from the MSWM point of view. For reuse and recycling, segregation of MSW into recyclables and organic/biodegradable stand essential. The ragpickers have been performing this duty of waste segregation. They pick up plastics, paper, cardboard, polythene bags, glass/plastic bottles, metals and other dry waste items whatever are saleable. It is beyond doubt that they are not doing this segregation job with a view to either helping recycling and reuse of MSW or planning for a pollution free environment, but for their own interest of earning, whether for livelihood or for pocket money. The working sites of ragpicking children and women in Nagaon town can be classified into 4 categories, viz. i. residential area, ii. Market/commercial area, iii. street, and iv. dumpsite. They sell the items picked up from those garbage sites to the local retail dealers, who pay them a nominal price. The pricelist as revealed by the present study on the 34 ragpickers in Nagaon town is as follws- plastics Rs. 15, cardboard Rs. 5, polythene Rs. 10, iron Rs. 20, copper Rs. 300, brass Rs. 220-250, and hendulium (popularly called aluminium) sells for Rs. 70-80 (all per kg). Bottles and some containers are sold for different prices for each piece- biscuit tin Rs. 20, beer bottle Rs. 2, glass bottle (750 ml) Re. 1, glass bottle (180 ml) Rs. 0.50, plastic bottle (2 litre) Re. 1 and 1 litre for Rs. 0.50 only (all per piece).

It is , therefore, a welcome phenomenon that the Ragpickers are reducing the wastes in quantity from the total waste generated in Nagaon town area , the quantity being 36 metric ton per day of which about 24 metric ton are reported to be transported for disposal. It indicates that a good portion from the remaining 8 metric ton is taken away daily by the ragpickers in Nagaon town. ‘If recyclable waste is collected recycled by groups such as ragpickers organizations, then the burden of waste transport and disposal are reduced’ (Ghosh, 2000).



Fig.11 **:** Photograph of child ragpickers sorting wastes at Nagaon town



Fig . 12 : A child ragpicker pulling rag-loaded tricycle



Fig. 13 : Ragpicker children selling waste to local dealer at Nagaon town

4.3.11 Conclusion and recommendation

It may be concluded that ragpickers have been playing a pivotal role in MSWM in Nagaon town by reducing the wastes in quantity from the total waste generated in the town area. They also perform the important task of segregation of degradable and non-degradable wastes greatly contributing to the reuse and recycling process.

Since any NGO/s or ragpickers' organistion/s has/have not come forward, the ULB itself should train up the ragpickers for waste collection and segregation and support them with proper protective wears such as gloves, mask, apron, boot etc. so that they can avoid health hazard as they are important stakeholders in the MSWM system. They can be issued identity cards as registered ragpickers under the ULB. It is of high expectation that UN/International organizations such as WHO, UNICEF, ILO etc. chalk out some special and effective programmes on the ragpickers with a view to improving the socio-economic status of the ragpicker community. It is worth mentioning that people will have to change their mindset so as to adopt at least the first two of the five 'R's (Refuse,Reduce,Reuse,Recycle,Recovery), and refuse plastic/polythene items and reduce wastes. The ULB should practice door to door collection and provide to households colour-coded bins for easy segregation at source. It can be expected that a garbage-free and ragpicker-free world will beckon. ❑

Abbreviation used:

ILO : International Labour Organization

MSW : Municipal Solid Waste

MSWM : Municipal Solid Waste Management

NGO : Non-Governmental Organization

ULB : Urban Local Bodies

UN : United Nations

UNICEF : United Nations International Children Emergency Fund

WHO : World Health Organisation

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Nudging a Bikeshare:
Behavioral Economics and Green Transportation

Jeremy Deaton
The George Washington University
jeremydeaton@gwu.edu

Abstract

As the global population becomes increasingly urbanized, city planners will need to expand clean public transit to serve their growing cities. Public bikeshare programs offer a cheap, green and convenient mode of transportation. However, many commuters refrain from joining bikeshare programs because their communities lack significant bike infrastructure or because they misapprehend the risks (or benefits) of using a bikeshare. This is true in Washington, D.C. where bikeshare members skew young, White, educated and male. Using the Washington bikeshare scheme as a case study, this paper examines barriers to using a public bikeshare. Drawing on recent work in behavioral economics, this paper then explores ways to "nudge" commuters to become bikeshare members. Expanding membership may motivate policymakers to improve bike infrastructure, thereby leading to greater usage. Strategies discussed here may illuminate ways to "nudge" other forms of green behavior.

Keywords: behavioral economics, bikeshare, nudge, transportation

Introduction

Over the coming century, the world will see a greater need for clean urban transport. The UN projects that of the 2.2 billion people expected to join the global population between 2000 and 2030, 2.1 billion will live in urban areas (UN DESA, 2002). A growing global population will contribute more and more to climate change. The UN Intergovernmental Panel on Climate Change projects the average global temperature will increase by at least 1.5º C before the end of this century, leading to more frequent and intense heat waves, droughts and cyclones, in addition to higher sea levels (IPCC, 2013). City planners will need cleaner modes of public transport, including trams, trains and public bikeshares.

Public bikeshares offer an emissions-free mode of urban transportation, though there exist multiple barriers to their widespread adoption. These include structural barriers, such as poor bike infrastructure, and policy barriers, such as policies that favor cars over clean forms of public transportation. Bikeshare operators should seek to expand usage of bikeshare programs in order to pressure public officials to expand bike infrastructure and implement public policy that favors bike and pedestrian traffic. This may be achieved through effective communication.

Using Washington, DC's public bikeshare scheme, Capital Bikeshare, as a case study, this paper will explore ways to expand bikeshare usage through "nudging." The brainchild of Cass Sunstein and Richard Thaler, "nudging" describes a means of steering individuals towards a specific behavior by triggering their automatic cognitive processes while preserving freedom of choice. That could mean changing the bikeshare enrollment process or the way bikeshare programs advertise. This paper will specifically focus on ways to reach demographics underrepresented among Capital Bikeshare's membership. Expanding bikeshare use may reduce vehicular pollution and promote public health. It may also motivate policymakers to improve bike infrastructure.

Bikeshare overview

Bikesharing schemes allow users to pick up bicycles at self-service rental stations and return them to other stations. Freeing users from the burden of maintenance and ownership, bikeshares work well for point-to-point trips (Burden & Barth, 2009). Today, roughly 375 bikesharing schemes operate in 33 countries, the vast majority serving commuters in Europe. Since 2008, bikesharing schemes have likely grown faster than every other form of urban transport (Midgely, 2011).

Despite that, bikesharing schemes have yet to prove especially profitable (Gifford & Campus, 2004), largely operating to supplement other forms of public transit. Bikeshares may be run by local governments, public transport agencies, non-profits, or in many instances, advertising companies. In the last case, a local government provides an advertising company with advertising space on bus shelters and billboards, and in exchange, those companies build and operate bikeshare systems (Shaheen, Guzman, & Zhang, 2010). It should be noted that while this may appear revenue-neutral, cities lose ad revenue by allocating free advertising space to bikeshare operators.

The primary goal of bikeshares is to reduce threats to public health and safety posed by motor vehicles. Automobiles contribute to congestion, pollution, injury, death and obesity. Bikes, by contrast, contribute little to traffic or pollution, provide users with exercise and require minimal infrastructure (Gifford & Campus, 2004). While bikes may not replace cars in all cases, they may be used for short trips, or in conjunction with public transportation. If cities make bikes easily accessible, that will help "integrate cycling into transportation systems, so that it can more readily become a daily transportation mode" (Shaheen, Guzman, & Zhang, 2010).

Bikeshares perform a very specific role in transportation schemes. Though the rising cost of gas continues to increase demand for public transit, bikeshares more often serve as an alternative to walking, rather than driving (Efthymiou, Antoniou, & Waddell, 2013). Bikeshares act as an extension

service, enabling commuters to comfortably traverse the distance from home to public transport or from public transport to work, a distance they may feel is insurmountable on foot (Shaheen, Guzman, & Zhang, 2010). Similarly, a commuter may use a bikeshare to replace a short leg of a longer journey on public transit, riding a bike instead of hopping on a public bus for the last two miles of his trip home. Research indicates commuters find time spent waiting or transferring significantly more burdensome than actual travel time (Moreau, 1992). By eliminating wait time for portions of one's commute, bikeshares improve the appeal of public transport as an alternative to driving.

Given their role in public transportation, it may come as no surprise that bikeshares have made little progress in appreciably reducing car use. Though half of car trips in the US fall short of five miles (Maibach, Steg, & Anable, 2009) and the average bike ride extends roughly two miles (Federal Highway Administration, 2001), bikeshares have yet to take a significant bite out of car use. Barcelona, Lyon, Montreal and Paris saw a mere 2 to 10 percent reduction in car use as a result of bikesharing. Commuters largely use bikeshares to replace other forms of public transit (Midgely, 2011). Moreover, a study of Montreal commuters revealed that 86 percent of bikeshare trips replaced other forms of sustainable transport (e.g. walking or taking the bus), which suggests the program only minimally reduced CO_2 emissions, one of the program's stated goals (Bachand-Marleau, Larsen, & El-Geneidy, 2011). However, an evaluation of Barcelona's bikeshare system estimated the program led to a reduction of 9 million kilograms of CO_2 emissions annually (Rojas-Rueda, de Nazelle, Tainio, & Nieuwenhuijsen, 2011).

Barriers to use

There are numerous barriers to commuters adopting bikeshares, not the least of which are climate and topography. Bad weather and treacherous hills can endanger riders and limit accessibility to more skilled cyclists at the exclusion of inexperienced riders or those with disabilities (Gifford & Campus, 2004). In cities with slopes between 4 and 8 percent, riders often ride downhill, but not up, so that bikes tend to collect at stations at low elevations (Midgely, 2011). This forces bikeshare operators to relocate bikes to high elevations regularly throughout the day.

There are also monetary barriers to bikeshare use. For efficiency and security, numerous systems use automated smart cards and electronic payment systems (Burden & Barth, 2009), many of which require a credit card to use. Low-income commuters often lack credit cards needed to access bikeshare systems, limiting access to higher earners, those more likely to own motor vehicles. Moreover, many systems offer discounted membership to low-income riders, but these often go unadvertised, and thus escape the purview of potential users (Rose, 2013). Consider that working families spend roughly 30 percent of their income on transportation (Lipman, 2006), a sum they could reduce by using bikeshares to supplant other forms of transportation. The average Washington D.C. bikeshare user reports saving $800 a year on transportation (LDA Consulting, 2013).

In addition to an income gap, bikeshares often see a gender gap. In the United States, male cyclists outnumber female cyclists three to one, likely because women are more risk averse than men (Baker, 2009). This may be because higher testosterone levels are positively associated with risk-taking (Sapienza, Zingales, & Maestripieri, 2009). As cycling poses a greater safety threat in the absence of dedicated bike infrastructure, countries with more developed bike infrastructure, such as Germany and the Netherlands, see a far higher proportion of female users (Baker, 2009).

Despite obvious threats to cyclists' safety, commuters stand to benefit from using a bikeshare. A study of Barcelona's bikeshare system (Rojas-Rueda, de Nazelle, Tainio, & Nieuwenhuijsen, 2011) found the program prevented 12.46 deaths annually as a result of increased physical activity, but led to an additional 0.03 deaths from traffic accidents and 0.13 deaths from pollution. Even short-term

exposure to air pollution can contribute to abnormal heart function (Weichenthal et al., 2011). However, the net effect of using a bikeshare is to lower one's risk of premature death.

Policy aids

There is ample room for policymakers to improve the appeal of public bikeshares, most notably by improving cycling infrastructure. Cycling is both safer and more popular in countries where "bikeways, bike lanes, special intersection modifications, and priority traffic signals are the key to their bicycling policies" (Pucher, 2001). As discussed here, a lack of dedicated bike lanes is particularly discouraging to potential female cyclists (Baker, 2009). Fifty-three percent of American women say they would bike more if there were more dedicated bike lanes. In New York in 2011, the proportion of female cyclists on streets with bike lines was twice the proportion on streets without bike lines (Szczepanski, 2013). Expanding bike infrastructure will measurably improve safety. Bicycle lanes are absent in more than half of collisions between cars and bicycles (Johnson, Charlton, Oxley, & Newstead, 2010). A study of cyclists in Montreal found that the risk of injury to cyclists was 28 percent lower on physically separated cycle tracks than it was on in-road bike lines (Lusk et al., 2011).

In addition to expanding bike infrastructure, cities may also encourage bike use by discouraging car use. While American cities, particularly younger American cities, have adapted their infrastructures to cars, European cities have largely adapted their infrastructures to pedestrians. Given their narrower roads, higher gas prices, and adherence to the Kyoto Protocol (which the US has yet to ratify), European cities have more incentive to reduce car use in favor of other forms of transportation (Rosenthal, 2011). The London congestion charge, aimed at reducing car traffic, led to a 30 percent increase in cycling (Santos, 2008). Other European cities have pursued similar bike-friendly policies such as closing streets to car traffic, converting car lanes to bike lanes and limiting parking (Rosenthal, 2011), in addition to lowering speed limits and giving cyclists priority at intersections (Woodcock, Banister, Edwards, Prentice, & Roberts, 2007). Regrettably, these trends have yet to cross the Atlantic. Cycling and walking receive less than 2 percent of federal transportation funding in the United States (Federal Highway Administration, 2010) despite accounting for 12 percent of all trips (Federal Highway Administration, 2009).

Policymakers may also consider the effect of climate on bike use. In developing its bikeshare system, Rio de Janeiro encountered resistance from members of the press arguing Rio was too hot for bikesharing to be feasible. (Biksehares had thus far seen their greatest success in the cooler climes of Northern Europe). The solution would be for schools, offices, malls and other public spaces to offer showers and changing rooms for cyclists (Sirkis, 2000). While this may, at first glance, appear a little impractical, it would be worth evaluating what effect this might have on encouraging bike use.

Policymakers may encounter political resistance in their effort to craft bike friendly policies. Bikes and bikeshares have become associated with the political left, and this may pose a barrier to their expansion. Cyclists are more likely to be city dwellers, and thus more likely to be liberal. In appealing to supporters, conservative politicians in the United States and Canada have made bikeshares political targets (Smith, 2013). Businesses often oppose expanding bike infrastructure because they fear giving up street parking to bike lanes will hurt business. However, as Don Shoup pointed out (1997), reducing free parking in favor of pedestrian and transit access allows individuals to spend more money locally. Bikeshare advocates might consider this, among other relevant facts, when appealing to conservative interests.

Advocates may find the best way to overcome political barriers is by expanding bikeshare use. When more commuters use bikeshare programs, policymakers are incentivized to expand bike infrastructure and discourage car use, while bikeshare operators are incentivized to add bicycles and

bikeshare stations. More stations and better bike infrastructure increase the appeal of bikeshare programs, thus drawing additional users. This virtuous circle begins by persuading commuters to give bikeshares a try.

Operators face numerous communications challenges in terms of encouraging widespread adoption. They must sway commuters with other, viable transportation options. They must sway commuters concerned about the risks of riding a bike. They must sway commuters living in communities with low bicycle use. In the following section, this paper will explore these issues as exemplified by Capital Bikeshare, the Washington, DC bikeshare scheme. In the American capital, bikeshare operators have struggled to achieve significant, widespread use. Capital Bikeshare members skew young, White, educated and male. Expanding bikeshare use in Washington, DC means finding a way to reach other kinds of commuters.

Capital Bikeshare

Washington DC hosted America's first major metropolitan bikeshare scheme, SmartBike DC, which was operated by ad giant Clear Channel. The program failed due to its small scale, poor promotion, and inaccessibility to tourists (DePillis, 2010) and was replaced by the larger Capital Bikeshare, run by Alta Bicycle Share in conjunction with local departments of transportation. Capital Bikeshare currently operates more than 1,800 bikes in Virginia, Maryland and the District of Columbia (Capital Bikeshare, 2014a).

Capital Bikeshare users constitute a fairly privileged bunch. Though less affluent than D.C. area commuters at large, bikeshare members do well by most other measures. Forty-five percent earn more than $100,000 per year. Roughly 95 percent hold a bachelor's degree, while 56 percent hold a masters or doctorate. Perhaps not surprisingly, 80 percent of bikeshare members are White (LDA Consulting, 2013), despite the fact that more than half of D.C. residents are African-American (Phillips, 2012). African-Americans constitute only three percent of bikeshare members (LDA Consulting, 2013). D.C. African-Americans see a median annual household income of only $37,000, and only 22 percent have earned at least a bachelor's degree (Phillips, 2012). This is troubling because Capital Bikeshare could help low-income commuters save a great deal of money on transportation.

The problem may be self-perpetuating. Non-White members are less likely than White members to report learning about Capital Bikeshare from a friend or family member and more likely to report learning about the program by seeing a bikeshare station (LDA Consulting, 2013). Non-White commuters may also be unable to join because they lack the necessary resources (Rose, 2013). An individual needs both a credit card and Internet access to become a Capital Bikeshare member, and while Capital Bikeshare offers financial assistance to low-income members, this fact is not especially well-advertised. Capital Bikeshare has reached out to Anacostia residents with discount memberships (Ross, 2012), but with unimpressive results. Predominantly African-American neighborhoods like Anacostia also see a paucity of bikeshare stations, especially when compared to predominantly White neighborhoods, like Arlington, Virginia. This is partly because Capital Bikeshare builds stations in areas with better bike infrastructure. Anacostia's narrow roads leave little room for bike lanes, and there are fewer points of interest in this neighborhood than in other parts of the DC metro area. (K. Lucas, personal communication, February 10, 2014). Moreover, unemployment rates in Anacostia hover around 25 percent (Neighborhood Info DC, 2012). Unemployed residents don't need a bike (or other form of transit) to get to work, further depressing bikeshare use. While the centrally located DuPont circle station sees thousands of users every month, there are stations in Anacostia which see fewer than ten (Capital Bikeshare, 2014b).

Low bikeshare membership among African-American commuters may reflect larger structural and cultural barriers to cycling for African-Americans. White Americans are roughly 50% percent more likely than African-Americans to ride a bike thirty minutes a day (Pucher, Buehler, Merom, & Bauman, 2011). “Commuters of color” (encompassing all non-White minorities) often live in neighborhoods lacking significant bike infrastructure. For this reason, the fatality rate for African-American cyclists is 30 percent higher than the fatality rate for White cyclists. Sixty percent of “commuters of color” report more bike lanes would encourage them to ride more, while 39 percent of “commuters of color” (as opposed to 20 percent of White commuters) report “learning about safe riding skills” would do the same (The League of American Bicyclists & The Sierra Club, 2013). These barriers to use may have engendered a culture of disdain for cycling (Mirk, 2009). African-Americans are more than twice as likely as aWhite Americans to report their perception of bicyclists would improve if cyclists represented a “broader cross section of Americans, such as women, youth and people of color” (The League of American Bicyclists & The Sierra Club, 2013).

Several groups have emerged to help close the race group in bikeshare use. Bank On DC, a non-profit that helps unbanked or underbanked DC households access financial services, has teamed with Capital Bikeshare and United Bank to offer discounted bikeshare membership to Bank on DC account holders and protect account holders from the full cost of losing a bike (Bank on DC, 2013). Back on My Feet, a non-profit that uses running to help homeless Americans (Back on My Feet, 2014), has helped homeless DC residents obtain bikeshare memberships (K. Lucas, personal communication, February 10, 2014). The Washington Area Bike Association runs an outreach program in Anacostia, East of the River, that encourages bike use, extends bike maintenance and offers bike education (WABA, 2013). Capital Bikeshare subsidizes this program (K. Lucas, personal communication, February 10, 2014).

In addition to skewing well-educated and White, Capital Bikeshare users also skew young. Younger members are less likely to possess a personal vehicle (car or bike) and more likely to be among the heaviest bikeshare users. They are also more likely to use Capital Bikeshare to make a trip they would not otherwise have made. For its youngest members, Capital Bikeshare serves a real utility. Younger members are more likely to cite saving money and getting around more easily as reasons for joining Capital Bikeshare, while older respondents are more likely to list health and environmental concerns. Older members are also more likely to indicate safety concerns (fast-moving cars, excess traffic on local roads, riding after dark) as barriers to usage (LDA Consulting, 2013). In total, young Americans are eschewing cars more and more in favor of bikes and public transit, especially when compared to their older counterparts. Remarkably, Americans between 16 and 34 take 24 percent more trips on bike than they did ten years ago, and they travel 23 percent fewer miles by motor vehicle (Davis, Dutzik, & Baxandall, 2012).

Finally, Capital Bikeshare members skew male (LDA Consulting, 2013). This is likely because, as discussed above, women on the whole tend to be more risk averse than men (Baker, 2009). Female Capital Bikeshare members are more likely than male members to list safety concerns as barriers to use (a lack of dedicated bike paths, excess traffic, fast-moving cars, and the danger of riding after dark). Women are also more likely to list health and environmental concerns as motivations for becoming members (LDA Consulting, 2013). Interestingly Capital Bikeshare users include a greater proportion of females than American cyclists at large, possibly because it serves a utilitarian purpose (Buck et al., 2013), though, because they tend to perform more household errands requiring a car, women may not view biking as a viable alternative to driving in the same way men do (Baker, 2009). Additionally, women in work attire may feel dissuaded from commuting by bike, though Capital Bikeshare bikes sport step-through frames to accommodate users in skirts (K. Lucas, personal communication,

February 10, 2014). Finally, it should be noted that casual bikeshare users (as opposed to members) skew slightly female, though they are also likely to be domestic tourists (Borecki et al., 2012).

Capital Bikeshare faces two major communication challenges. First, Capital Bikeshare has failed to reach non-White commuters, many of whom would likely benefit financially from using Capital Bikeshare. This is due in part to structural barriers (the difficulty of becoming a member, the relative paucity of bike stations in predominantly African-American neighborhoods), but it may also reflect a failure to market to this audience. Second, Capital Bikeshare has failed to reach women and older commuters. Both of these groups are more dissuaded by threats to their safety than young men, but they are also more motivated by possible benefits to their health and the environment. The program has yet to capitalize on this fact. Here again, Capital Bikeshare must face structural barriers. Many members report not wearing a helmet because it is inconvenient to carry one around. (Trips are mostly unplanned.) Because older members and women are more likely to wear a helmet than young men (LDA Consulting, 2013), they may be more likely to balk at riding a bike when lacking protection. Offering helmets to be publicly shared poses a risk to public health. Thus, this issue may permanently limit use among women and older commuters.

Nudging Capital Bikeshare

While Capital Bikeshare would like to reach a more diverse assortment of commuters, the program invests little in advertising. Bikeshare stations currently sport ads for Capital Bikeshare, but DDOT will eventually replace those ads with revenue-generating commercial advertisements. Capital Bikeshare expends little energy expanding membership, and most advertising takes the form of targeted mailers intended to balance stations by encouraging use at stations that lose or gain most or all of their bikes during morning or evening commutes (A. McLaughlin, personal communication, February 10, 2014). If there is a bikeshare station in your neighborhood, you are likely aware of the program, and if you don't, it's probably of little use to you. Nonetheless, many potential members lack information on how the program works, who runs Capital Bikeshare or how to sign up (K. Lucas, personal communication, February 10, 2014). The question then becomes how to motivate broader use more effectively and with little expense.

"Nudging," a concept pioneered by Cass Sunstein and Richard Thaler, has captured the imaginations of academics and policymakers alike, and it may prove useful to expanding bikeshare use. Sunstein and Thaler (2008) describe nudging as "libertarian paternalism," a means of urging an individual towards a specific behavior (say, enrolling in a 401k or joining a bikeshare) by triggering his automatic cognitive processes while preserving his freedom of choice. They draw on research from behavioral economics showing that individuals often "make inferior decisions in terms of their own welfare — decisions that they would change if they had complete information, unlimited cognitive abilities and no lack of self-control" (Sunstein & Thaler, 2003). Communicators and policymakers must operate with an awareness of the implications of "bounded rationality" (John et al., 2013). That is to say, they must make the most rational (i.e. healthiest, most prudent) decisions the most convenient and obvious. When it comes to using a bikeshare, there is ample room to nudge commuters towards better decisions. Many commuters prefer cars to bikes and public transit because they underestimate the cost of ownership in terms of money, safety and environmental impact (Parry, Walls & Harrington, 2007). Making these impacts more salient may motivate healthier decisions. Making healthier decisions more convenient do the same.

In practice, this could be as simple as automatic enrollment. Given that bikeshares act as an "extension service," allowing commuters to reach other forms of public transport more easily

(Shaheen, Guzman, & Zhang, 2010), it would make sense if enrollment in Capital Bikeshare were paired with the purchase of a Metro card. Given that people often choose mindlessly (Wansink, Van Ittersum, & Painter, 2006) and are inclined towards defaults (Thaler & Benartzi, 2000), the DDOT, which operates both the Metro and Capital Bikeshare, could automatically enroll those purchasing Metro cards into Capital Bikeshare. Commuters would retain the option to not enroll, but enrollment would become the default. Conveniently, both Metro card purchases and bikeshare memberships are billed to one's credit card, which is helpful because if people must experience pain (such as the pain of an expenditure), they prefer to do it in the future (Frederick, Loewenstein & O'Donoghue, 2002). When Metro riders receive their SmarTrip card in the mail, they would also receive a Capital Bikeshare key. This tactic works by changing the choice architecture, removing barriers to joining the program so that bikeshare membership lies along the path of least resistance. Potential members need not seek out the Capital Bikeshare website or re-enter their payment information. Attaching bikeshare enrollment to the purchase of a Metro card ensures commuters can join the program with no additional effort. This could draw a considerable number of new members from the large and diverse pool of Metro users. Next, let's consider how to target specific demographic gaps in Capital Bikeshare's membership.

Appealing to women and older commuters

As discussed here, women and older bikeshare users are more likely to list health and environmental concerns as motivations for becoming members and are more likely to list safety concerns as barriers to use (LDA Consulting, 2013). Bikeshare operators might nudge bikeshare use among women and older commuters by demonstrating that the health and environmental benefits of cycling far outweigh its risks. In order to be effective, they must make persuasive information available at the time of consumption (Thaler & Sunstein, 2008). For example, giving individuals immediate feedback on their energy consumption was shown to produce a 5 to 15 percent reduction in energy use by allowing those individuals to associate their behavior with its relevant costs in real time (Darby, 2006). This must be done repeatedly in order to motivate a lasting change of behavior (John et al., 2013). In addition to making relevant information more salient, bikeshare operators should also encourage people to make commitments, which has also been shown to change behavior (Dawney and Shah, 2005). In this way, nudging functions as a tool of persuasion.

Consider how this would play out with regards to the health benefits of using a bikeshare. As mentioned above, a study of Barcelona's bikeshare system showed using the bikeshare is more likely to prevent fatality by increasing physical activity than it is to cause a fatality through traffic collisions or exposure to air pollution (Rojas-Rueda, de Nazelle, Tainio, & Nieuwenhuijsen, 2011). Given that no one has ever died using Capital Bikeshare, and there have been fewer than 100 reported accidents in 6 million trips (K. Lucas, personal communication, February 10, 2014), it would be safe to presume using Washington's bikeshare system similarly reduces one's risk of mortality, and improves his overall health. Consider that one third of Capital Bikeshare users report losing weight since becoming members (Alberts, Palumbo, & Pierce, 2012). Many people commute actively for "health benefits" (Anable and Gatersleben, 2005), and yet safety concerns weigh heavily on the minds of women and older Capital Bikeshare members (LDA Consulting, 2013). Given the net health benefits of bikeshare use, this concern represents a sort of "probability neglect" (Sunstein, 2003). Commuters are more swayed by the visceral danger posed by cars than the greater, though more abstract, danger posed by a sedentary lifestyle.

In order to combat this, bikeshare operators should make the health benefits of using the program more salient. Capital Bikeshare records the duration, distance and estimated calories burned for every trip. The program could email each user after every trip with information on the number of

calories he or she burned, using images of calorically equivalent foods to illustrate the benefits of riding a bike (e.g., the calories burned on a fifteen-minute trip are equivalent to those in one small cookie). These emails could also emphasize the effect of exercise on reducing risk of any number of deadly diseases. Additionally, where making commitments can lead to changes in behavior (Dawnay and Shah, 2005), users should have the option of setting a goal for the number of calories burned in transit over a given period of time (say, one month). Emails would update the user on her progress towards her goal, using graphics (say, a meter leaning ever closer to the user's goal) to represent progress visually. Users should be automatically enrolled in these emails with the option to unsubscribe through the Capital Bikeshare website.

A similar tactic could be applied to making the environmental benefits of using Capital Bikeshare more salient. In addition to recording the estimated number of calories burned for every trip, Capital Bikeshare also records the estimated pounds of CO_2 offset by every trip (assuming the trip replaced a car ride). As with emails detailing the health benefits of cycling, bikeshare operators should represent the pounds of carbon dioxide offset by cycling visually (e.g., a fifteen-minute trip offsets 30 balloons worth of carbon dioxide). Where more "environmentally conscious" individuals are more likely to join bikeshare schemes (Efthymiou, Antoniou, & Waddell, 2013), and women and older commuters list environmental benefits among their chief motivations for use (LDA Consulting, 2013), this should redound to increased bikeshare usage. Informing commuters of the environmental impacts of their form of transport has been shown to affect route choice (Gaker, Zheng, & Walker, 2010).

Appealing to users environmental concerns also allows bikeshare operators to invoke the power of social norms. Considerable research illustrates the effect of appealing to descriptive (as opposed to injunctive) norms. Consider Gerber, Green and Larimer's 2008 experiment showing that publicizing an individual's voting behavior increases the likelihood that he will vote. A similar study (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007) shows that informing individuals how their energy consumption compares to the neighborhood average can motivate heavy users to reduce their consumption. Its authors argue that people underestimate pro-social behavior among their peers and then judge themselves by those low standards. As Thaler and Sunstein (2008) explain, people are influenced by their perception of the behavior of their peers, and their concern for what their peers think of them. Capital Bikeshare might capitalize on this phenomenon by showing users how much carbon dioxide they have offset as compared with others in their area. They might inform users how their performance compares to the system average, or they might list the top ten users per week at a given bikeshare station. Most importantly, Capital Bikeshare must make relevant information about the health and environmental benefits of bikeshare use immediately available in order to affect behavior.

Appealing to African-American commuters

As discussed above, African-American commuters may refrain from joining Capital Bikeshare because they are unfamiliar with safe riding skills, live in neighborhoods lacking significant bike infrastructure and see few of their peers using Capital Bikeshare. It may be helpful to illustrate how commuters might safely use Capital Bikeshare in their daily lives, through individualized travel marketing. Individualized travel marketing (ITM) works by finding individuals interested in trying (in this case) more active transport, and then providing those individuals with customized information, such as a cycling map showing a safe route to and from work. An Australian ITM program was found to reduce car trips by 9 percent and increase bike trips by 61 percent, remarkably, at a cost-benefit ratio of 1:13 (Thøgersen, 2007). Capital Bikeshare might automate this process by inviting potential members to submit their home address and work address online and then using that information to produce a map showing how Capital Bikeshare might be integrated into their daily commutes.

Even if the potential member needs a train or bus to make part of the trip, he might be enticed by the possibility of using Capital Bikeshare to shorten his commute, or to replace short bus rides or long walks with cycling. Gaker and Walker (2011) recommend bikeshare operators put the length of bike rides in context. They argue "people might avoid taking a 20 minute bike-ride over a 15 minute drive, but they would prefer riding a bike to spending 30 minutes on a bus." Moreover, simply showing potential members how to navigate the system might break down barriers to use. A study of Japanese commuters showed that giving individuals free bus tickets to teach them how to use the public bus resulted in many commuters continuing to use the bus after they stopped receiving free tickets (Fujii & Kitmura, 2003). Capital Bikeshare might be able to accomplish the same feat without extending free membership. They simply need to show potential members how to get around.

This strategy could then go one step further by demonstrating how much a potential member might save by joining Capital Bikeshare. As discussed above, the average Capital Bikeshare user reports saving $800 a year on transportation (LDA Consulting, 2013). Given that DC's African-American residents are, on average, considerably less affluent than their White counterparts (Phillips, 2012), they may be motivated by the prospect of saving money. Thaler and Sunstein (2008) point to the EPA's fuel economy stickers for new cars as an example of how to nudge economically savvy transportation decisions. Stickers on new, unsold cars show the annual cost of fuel as compared with similar cars in order to encourage consumers to purchase more fuel-efficient vehicles. Bikeshare operators might try a similar approach, advertising the annual projected savings of replacing short car, bus or train trips with bike trips. This may be combined with ITM's to show how using a bikeshare to get to and from work would save commuters money. The ITM would both illustrate how to incorporate a bikeshare into one's daily commute and the estimated daily, month and yearly savings of becoming a member. Given humans' propensity towards loss aversion (Tversky & Kahneman, 1991), it might be effective for bikeshare operators to frame the status quo ongoing loss (e.g. "You lose $800 a year by not becoming a bikeshare member"). In doing so, they make the most rational choice, becoming a member, the most obvious.

Conclusion

Regarding Capital Bikeshare, there may be some temptation to appeal exclusively to those most likely to join the program—young, educated, White men—instead of reaching for a broader audience. Narrowing focus to the low-hanging fruit may draw new members faster, but there is good reason to believe it won't expand usage to other demographics. Everett Rogers (2010) points out that homophily causes ideas to spread horizontally (among like individuals), rather than vertically (between different groups). Rogers (2010) also argues that when considering a new idea, "individuals depend mainly on the communicated experience of others much like themselves who have already adopted a new idea" (p. 331). If Capital Bikeshare wishes to draw a more diverse group of users, they must reach out to different demographics with targeted strategies. This is especially true in racially segregated Washington, DC.

Of course, the American capital is just one venue for the strategies discussed here. These strategies may be applied to bikeshare systems all over. Bikeshare operators can attract low-income commuters with the promise of savings, and they can attract women by putting the risks of riding a bike in context. Nudging offers an elegant means to reach these groups by making the benefits of bikeshare use more salient. Indeed, the central challenge of promoting a bikeshare program is that its benefits are often hidden while its apparent risks take center stage.

To that end, the nudging strategies outlined here may serve as yet another example of how nudging may be used to grapple with environmental issues. Humans often pollute because the

consequences of their actions are not immediately obvious to them. Americans, for example, largely regard climate change as a temporally and geographically distant problem (Leiserowitz, 2005). When Americans perceive the effects of climate change as having no personal impact, they are less likely to make the sacrifices needed to stave off global catastrophe. This is especially problematic given that people would rather make sacrifices in the future than in the present (Frederick, Loewenstein & O'Donoghue, 2002). Nudging turns these problems around, making the consequences of inaction immediate while delaying the pain of action. The strategies discussed here offer just one way to go about doing that. Applied to other environmental issues, nudging can guide us to a cleaner, greener, safer future.

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OFF-GRID WIND TURBINE INSTALLATION AT CAMPUS DO VALE OF FEDERAL UNIVERSITY OF RIO GRANDE DO SUL

Monir Göethel Borba[1] – monir.borba@ufrgs.br

Felipe Guimarães Ramos[1] – felipe.ramos@ufrgs.br

Franciele Weschenfelder[1] – franciele.weschenfelder@ufrgs.br

Franciele Peruchi Ronchi[1] – franciele.peruchi@ufrgs.br

Lírio Schaeffer[1] - schaefer@ufrgs.br

[1] Metal Forming Laboratory. Metallurgic Engineer Department. Federal University of Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.

Abstract

The present paper aims the installation of a wind turbine GERAR246 on Campus do Vale of Federal University of Rio Grande do Sul. Will be presented the parts that compose the wind generation system such as the battery charge controller and inverter that was developed for processing of alternating current in continuous current. The installation of this wind turbine has as objective the evaluation of its performance before a trial period with parts from the factory and parts developed in the laboratory of Mechanical Transformation of the Federal University of Rio Grande do Sul through powder metallurgy.

Keywords: wind power, wind turbine, GERAR246, installation.

1. Introduction

The installation of a small wind turbine for electric power generation off-grid in the Campus do Vale of the Universidade Federal do Rio Grande do Sul was carried out by the engineers in renewable energy development group (GDER) and is part of the project "development of materials obtained from powder metallurgy processes applied to micro pieces in the medical field and small wind turbines up to 10KW". This equipment is called off-grid because it has no communication with the traditional power grid. One of the main objectives in the area of small wind turbines is the use of the technology of powder metallurgy. There is a concrete possibility that wind turbines may be produced with a higher yield, lower cost manufacturing and increased performance. The installation of the wind turbine is the first step in the research of replacement of parts produced in the conventional way by another obtaining through powder metallurgy.

2. Wind energy

Since the dawn of humanity the man seeking the best solution of your problems through new technologies. For this, it is necessary to acquire technical and scientific knowledge in order to modify and enhance the use of tools, processes, resources and new materials. The evolution of the human species is closely related to the use of natural resources, because any object to be created the appropriate natural resource needs. Technological development comes from meeting with the need of solving problems. The wheel is one of these examples. No one knows for sure who invented it and when this occurred, but it is recognized the developments were comes with it and it is impossible imagine what it would be like the modern world without their design. Nor is it possible to imagine the present day without the use of a very important natural resource: the wind. The era of the great navigations and maritime voyages of discovery was only possible with the use of the force of the wind, which was moving ships across oceans. The windmills also have fundamental importance regarding the use of the wind, because they were the forerunners of today's wind turbines.

The energy that comes from the winds is called wind energy. The etymological origin of the word is Latin and derives from *aeolicus*, which makes references to something belonging or pertaining to Greek God of the winds Aeolus. The winds at the planet Earth originates from the uneven heating of the planet surface that is exposed. The energy from the sun is absorbed by the earth or water is transferred to the atmosphere, being that the tropics recently a greater amount of solar radiation than the poles due to the inclination of 23º45' from the axis of rotation of the planet relative to the plane of orbit around the Sun. The heating of the air mass that is located over the tropics causes an increase of pressure in this region, causing the hot air moves to a distance of 10 to 15 kilometers above the Earth's surface. This air flow originating in the tropics moves towards the poles and results a decreasing pressure in the region of the tropics and increasing in the polar region. As a result also occurs a flow of air of the polar region for the tropical region. This air circulation occurs whenever there is a difference in temperature between the tropics and the poles. These airflows occur approximately every 30 degrees of latitude. The figure 1 presents the three main circulating cells of the winds. Tropical cells are responsible for producing winds from the southwest in the southern hemisphere and winds from the northeast in the northern hemisphere, also called trade winds. Temperate cells produce the called westerlies, with almost opposite directions to tropical cells, prevailing winds northwest and southwest in their southern and northern hemispheres. The last cell is called a polar, characterized by a polar anticyclone with winds from the east. Around the equator line have a belt with light winds, called a belt of lulls.

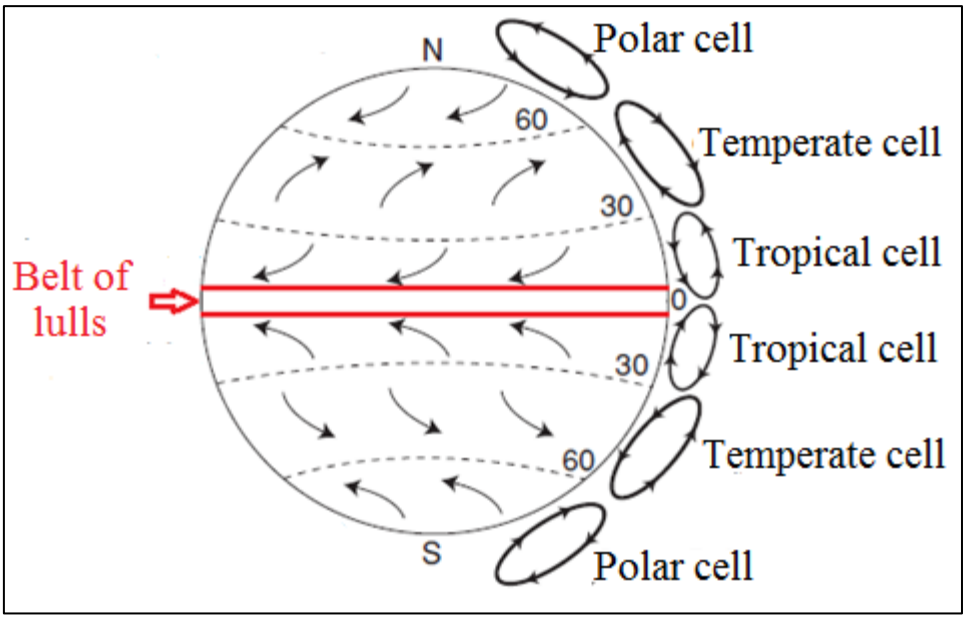


Figure 1 – Circulation of winds on Earth

3. Wind turbines

The development of a machine capable of converting the wind kinetic energy into mechanical energy goes back hundreds of years ago. There is a divergence between authors as to the time when there was the initial use of this technology. Custódio (2009) points the year 3.000 B.C. as the time of the first use by the Egyptians, while Delhi (2001) mentions the use of rudimentary mills in China around the year 2.000 B.C. and in the Babylonian Empire around 1.700 B.C. and Kaldellis and Zafirakis (2011) cite that vertical-axis mills were found in Persian-Afghan borders in 200 B.C., although there is a dispute as to the time of initial application the authors agree that the wind was initially used for grinding grain in mills, changing human or animal strength by the force of the winds and also for lifting water.

With the passing of time and the changing needs of man, wind energy is no longer, for the most part, converted into mechanical energy and went on to be converted into electrical energy. The evolution of wind turbines has brought several variations to this equipment. Wind turbines can be classified in two main areas: the way the wind focuses on your blades and orientation of the axis of rotation. Each turbine configuration offers advantages and disadvantages that must be taken into account in selecting the most appropriate turbine. Currently there is a predominant wind turbine configuration for converting wind energy into electrical energy, too found in wind farms around the world.

The way that wind focuses in blades divides the wind turbines between drag type or support. Drag turbines are those in which the wind pushes the blades, forcing the spinning rotor. The rotor speed cannot exceed the speed of the wind, being this a limiter of its efficiency, having applications in small volumes of water pumping from low-speed winds. Support applying in the airfoil concept, using them as blades. The wind focuses in blades with an angle in relation to the blade axis, making the air flow move the rotor. This is the model most found, being used for large-scale power generation.

The orientation of the rotor shaft of the wind turbines is divided into two types: vertical axis turbines and horizontal axis. Vertical axis turbines no need arrangements for the orientation in relation to wind direction. Have the generator and others equipment installed in the soil, making it easier in case of maintenance. The rotors with horizontal axis need be kept perpendicular to the direction of the wind, so they can extract maximum power. Will be installed in large towers with

heights variants, depending on the height where there is more power in the wind. Is commonly used in large power plants for electric power production. Horizontal axis wind turbines may have settings with different numbers of blades, ranging from one, two, three or multiple blades. The number of blades on a wind turbine depends on the type of application that needs, because it influences the performance of the wind turbine. The advantage of a larger number of blades is that they help to increase the torque on the rotor shaft. The disadvantage in the increase the number of blades is that a blade running in the space previously occupied by another blade, crossing a disturbed air and this reduces the speed of the rotor, that is, the smaller the number of blades faster the rotor spins. For the generation of electric power needs of high speed and low torque, is recommended to use turbine with few blades. For the pumping of water needed a large torque and low speed, found in turbines with multiple blades.

The wind turbine that was installed on Campus do Vale of Federal University of Rio Grande do Sul is the model GERAR246l, produced by Enersud. Its main characteristics are listed in table I. There are also its mechanical robustness, efficiency in power generation, low noise and extremely reliable security system. Another point in favor of this equipment was its easy assembly, which was held by people without experience in the installation of wind turbines. The GERAR246 is great application on conversion of the force of wind into electrical energy for lighting, electrification of fence, security systems, water pumping, among others.

Table I – Main characteristics of wind turbine GERAR246

FEATURE	VALUE
Propeller diameter	2.46 m
Power with wind of 12 m/s	1000 Watts
Rotations with wind of 12 m/s	630 rpm
Number of blades	3
Type of blades	Twisted (airfoil 5)
Starting speed	2.2 m/s
Starting Torque	0.3 Nm
Speed control	Stall
Protection against high speeds	Active stall (pitch control)
Electric system	Three phase
Alternator	Axial flow
Output voltage	12, 24, 48 or 300 V
Total weight	32 Kg
Alternator	Axial flow



Figure 2 – Wind turbine GERAR246

4. Installation

The starting point for the installation of the wind turbine was the construction of the foundations necessary to support the tower. The basis for the tower was built with dimensions of 1.5 m x 1.5 m x 1 m. These dimensions were suggested by an engineer from a company that works with equipment installation for renewable energies and has experience in the process of installing wind turbines of this manufacturer. The tower that was selected for installation is self-supporting, has a mobile base that allows its change of position only with the help of a munck truck. Therefore it was necessary to prepare four pieces of metal and attached them to the base of the tower for a greater mechanical resistance.



Figure 3 – Excavation and concreting of the tower base



Figure 4 – Self-supporting mechanism

The tower is composed of two parts of 6 meters each, totaling 12 m of high and has been fixed supports for stay in point of union of the two pieces. The wind turbine was dismantled, to facilitate transport from the factory to the lab and was assembled directly in the tower before it was erected by a truck munck.



Figure 5 – Union of tower stay supports



Figure 6 – Wind turbine disassembled



Figure 7 – Assembling the wind turbine on the tower



Figure 8 – Munck truck holding the tower with the wind turbine

With the tower up, was finalized the process of installation of the tower with the fixing screws of the base.



Figure 9 – Support screw

5. Charge controller

The energy that comes from the wind turbine has as main purpose to feed the loads that are connected by consuming energy. The extra energy produced that is not consumed is used for battery charging. For the correct administration of the flow of energy within the system are used devices called charge controller. The primary function of a charge controller is to protect the batteries from extreme situations and protect for the changes in the seasonality of consumption profile and temperature. These precautions help to increase the lifespan of the batteries.

The controller used in wind turbine was developed by own wind turbine manufacturer and provides a continuous voltage control that is delivered to the batteries. If necessary, the excess of energy produced is thrown through resistors. These continuous controls set how much energy should be discarded and maintain the battery voltage at a great value. The controller is equipped with a selector switch which, when thrown, brake the wind turbine. This electric brake is triggered manually by a responsible when there are thunderstorms forecast with gusty winds too strong, in order to maintain the integrity of the equipment.



Figure 10 – Charge controller (white) for wind turbine dissipation resistors

6. Inverter

The wind turbine produces a three-phase voltage of 24V. So that the batteries can be charged, the charge controller is AC/DC type, i.e. performed the conversion of alternating current to continuous current. The kind of current required for the battery charging is not the correct current for some conventional electrical equipment work. There are electronic devices that were designed to operate on 12 or 24V continuous current, but they are few. Faced with the need for a voltage of 127 or 220V alternating current is necessary to use a device called an inverter. In large power systems (up to 5KW) the greater advantage in the use of inverters for the fact that there will be a decrease in the section of the cables for connecting the loads long distances because the tensions of operation of alternating current circuits are higher and consequently with smaller chains.

For the correct sizing of an inverter, it must be considered: waveform at the output, efficiency, nominal output, utilization rate, input voltage, output voltage and frequency of the output signal. The waveform at the output makes references to the type of the inverter according to characteristics of AC voltage produced. Are commonly found square wave inverters, modified sine and square or rectangular. The power conversion efficiency varies with the type of load and is found with equipment efficiency between 50 to 95%. The nominal heat output indicates the power that the inverter can supply charge. Preferably the inverter must be sized to provide a superior power, but next demand peak needs. The utilization rate of the inverter indicates the amount of hours that the inverter can operate at their maximum power. This fee must be respected to avoid system crashes. The input voltage of direct current can be supplied by wind generator or by batteries. The output voltage should be according to the voltage of the equipment available. Finally, the output signal frequency depends on the geographic location of the installation. In Brazil uses the frequency of 60 Hz, same pattern of the United States and Europe is used the frequency of 50 Hz.

As the purpose of the study of this wind turbine is to evaluate your performance with new pieces and not for the purpose of residential supply was sought a more economical solution and that is grossing more knowledge. It was found in a disposal of the university an uninterruptible power supply APC brand, model Back-UPS RS 1200. When trying to diagnose the problem that would make this equipment is dropped, it has been found that the batteries were not retaining more cargo, but their electronic pieces were in perfect condition. The batteries in this UPS 24V was direct current, were exactly the same configuration of the wind turbine batteries. After some technical adaptations, old batteries were removed from UPS and redone a few electrical connections to the batteries of the wind turbine should act as the originals in the ups. Because it is an action that aimed to increase the life cycle of equipment that was destined for recycling and that it was not designed for this function, only a desktop computer is connected to this equipment. The use of no-breaks as frequency inverters is not recommended, because this type of equipment has been developed to address energy shortages for small periods of time.



Figure 11 – uninterruptible power supply used as inverter

7. Meteorological monitoring

The meteorological phenomena that occur around the wind turbine can be monitored with the use of instruments developed for measuring and recording of climatic variables. The meeting of

these sensors receives the title of meteorological station, and may contain temperature sensors, barometric pressure, relative humidity, wind, solar insolation, rainfall, among others. The data obtained from these sensors are used to the weather, and can be transmitted directly to a computer or stored in data loggers. With the help of specialized software it is possible to perform the interpretation of collected data, generating reports on weather conditions in the particular location.

For monitoring of wind turbine on Campus do Vale of UFRGS was held to purchase a weather station La Crosse brand, model WS-2815U-IT. This model of station has features like sensors for measuring internal and external temperature (minimum and maximum), relative humidity of internal and external air (minimum and maximum), dew point, wind-chill factor caused by wind, barometric pressure (minimum and maximum), direction and wind speed and rainfall data. Can cite as other features the possibility to use configurable alarms for warning of certain weather conditions such as storms. The monitoring of weather information can be done both at the location of the measurements through the display of meteorological information as Heavy Weather Pro software on a computer or remotely via a web site.

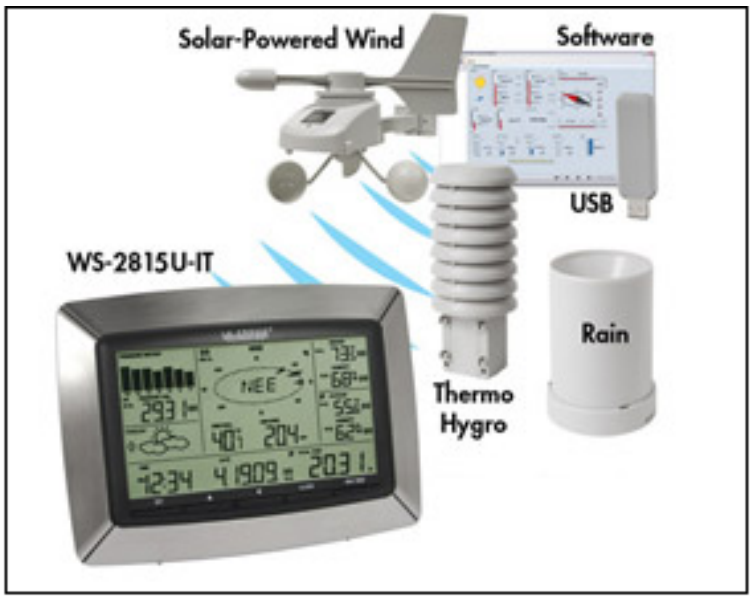


Figure 12 – weather station components

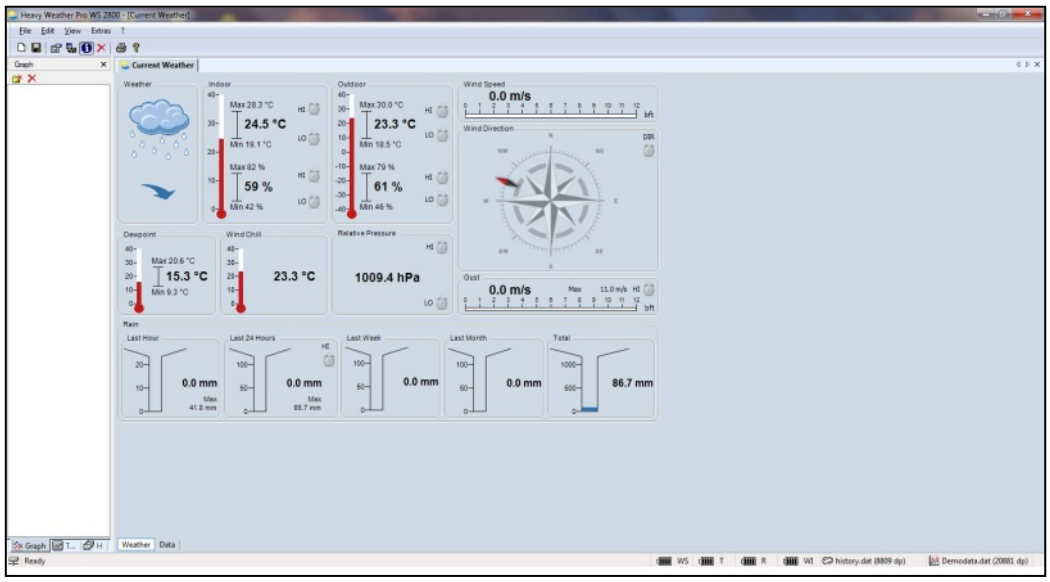


Figure 13 – Screen of data analysis supervisory

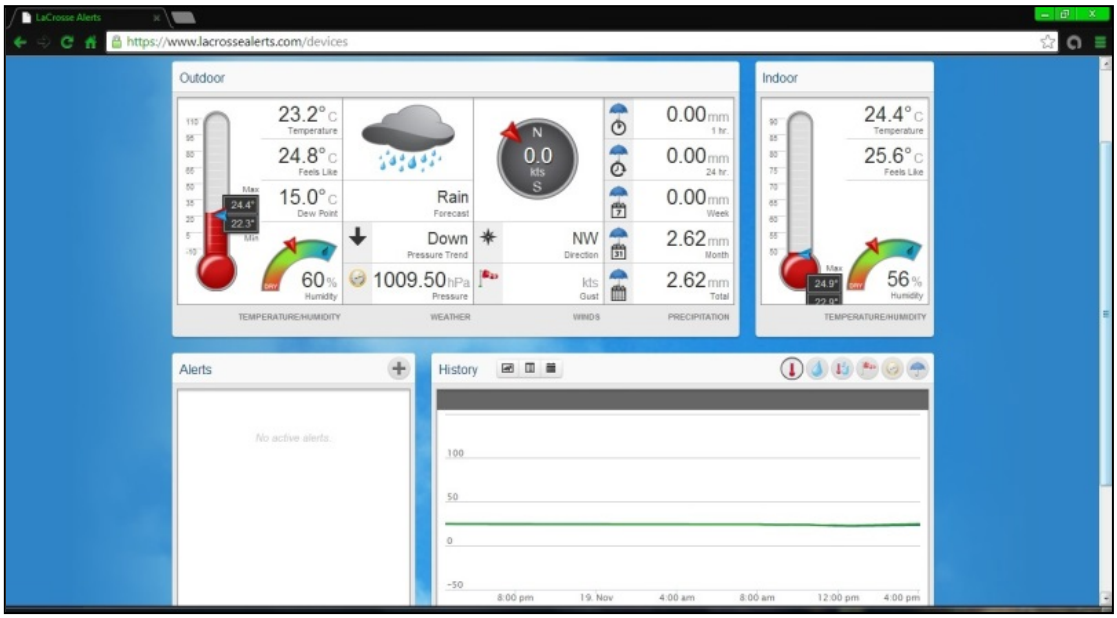


Figure 14 – Remote monitoring website

8. Conclusions

The installation of a wind turbine at Campus do Vale of the Federal University of Rio Grande de Sul brought a very valuable experience not only for the researchers involved, but also for future research in this area. Despite being a small installation, it was offered to the involved researchers the opportunity to experience the step by step of the installation, which encompassed since contact with the company through the acquisition of tower type, determination of the place of installation, construction of foundations, hoisting the tower and wind turbine, electric installation and recycling of an inverter for use as equipment and meteorological monitoring system.

For the correct operation of the power generation system, the charge controller features an immeasurable importance, because it is responsible for managing the amount of energy that will be delivered to the loads, the amount necessary to ensure that the batteries are always fully loaded and perform the disposal of surplus energy when needed. The company Enersud, wind turbine manufacturer, has developed a controller that meets the requirements of your wind turbine, facilitating and optimizing the integration of the equipment.

The equipment reconfigured to operate as inverter in wind power generation system has presented a satisfactory performance. For an inverter to be regarded as good, he must have pure sine wave output and low total harmonic distortion. These two aspects ensure a smooth operation, safely and efficiently, avoiding any reduction in service life of the loads. In order to recycle the UPS was not to dump garbage in an outfit that featured a pure sine wave output, thus serving a prerequisite for obtaining a high-quality inverter. With the adaptation of the UPS was possible to reuse an outfit that had the trash like destiny. This equipment complies with twice the role of helping nature: no longer generate solid waste and now converts the energy of the wind turbine to be used for household equipment. This adjustment is not recommended, because you don't know the reliability that this equipment is not designed by the manufacturer to be an inverter.

The observation of weather conditions has important significance for the understanding of how the wind turbine is operating. Weather station acquired for this project presents a fairly complete solution, featuring essential, such as sensors, anemometer, temperature sensor and barometric pressure sensor. Remote monitoring of these sensors extends the care you get from the wind turbine, which always seeks to preserve the equipment so that it can remain as long as possible running and providing power. Remote monitoring also allows the sharing of information with

others who have an interest in knowing the microclimate in the region of the Valley Campus of the Universidade Federal do Rio Grande do Sul.

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Author's biography

Monir Göethel Borba – Master student at Mining, Metallurgical and Materials Engineering at Federal University of Rio Grande do Sul in Renewable Energies Development Group, working with materials for renewable energy. He is graduated in Control and Automation Engineering at Pontifical Catholic University of Rio Grande do Sul. The main areas that he studies are wind turbines, powder metallurgy and renewable energies. He is member of the organizing committee of the 4th International Conference on Materials and Processes for Renewable Energy.

Felipe Guimarães Ramos – Master student at Metallurgical and Materials Engineering from Federal University of Rio Grande do Sul in Renewable Energies Development Group. He is graduated in Control and Automation Engineering at Pontifical Catholic University of Rio Grande do Sul. He is member of the organizing committee of the 4th International Conference on Materials and Processes for Renewable Energy.

Franciele Weschenfelder – M.Sc in Mining, Metallurgical and Materials Engineering by Federal University of Rio Grande do Sul. She is graduated in Renewable Energy and the Environment Engineer at the Federal University of Pampa (UNIPAMPA) in Bage - RS. She is also technician in biofuels by the Rio Grande Southern Federal Institute.

Franciele Peruchi Ronchi – Master student at Mining, Metallurgical and Materials Engineering at Federal University of Rio Grande do Sul. She holds degrees in Electrical Engineering from the University SATC. She is engineer researcher at Development Group on Renewable Energy (GDER), part of the Mechanical Transformation Laboratory (LDTM) - UFRGS. Have experience in low voltage electrical projects. She is member of the organizing committee of the 4th International Conference on Materials and Processes for Renewable Energy.

Lírio Schaeffer – Mechanical Engineer, D.Sc. in Mechanical Forming - Rheinisch-Technische Hochschule Westfälischen, Aachen - Germany. Since 1976 is Professor at the Federal University of Rio Grande do Sul - Department of Metallurgy and coordinator of Laboratory of Mechanical Manufacturing (LDTM), working mainly in the following areas: forging, stamping, powder metallurgy, biomedical materials. Have experiences in alternative energies. Currently is ad hoc consultant of the Foundation for Research Support of the State of Rio Grande do Sul (FAPERGS), Coordination for the Improvement of Higher Education Personnel (CAPES), consultant to the National Council for Scientific and Technological Development (CNPq) and Consultant Foundation for Research Support of the State of Rio de Janeiro (FAPERJ).

Planning and Creating a Sustainable Future: The Development and Implementation of a Multi-Billion Dollar Green Life Sciences Campus

Mark B. Williams

Abstract:

Every university develops plans to guide growth. However, the juncture of planning and implementation reveals the true lessons, best practices and pitfalls of those plans. After five years of planning, Oregon Health &
Science University (OHSU) is now engaged in a multi-billion dollar expansion in a former brownfield on the Portland waterfront. Linked by an innovative $57 million aerial tram and developed through partnerships with local jurisdictions and private investors, OHSU is leveraging billions of dollars in public and private investment to create a highly sustainable life sciences campus where:

- ☐ A postindustrial brownfield is transformed into a highly sustainable green neighborhood, complete with health care, academic institutions, housing, and thousands of good jobs.
- ☐ Top researchers and clinicians from around the world develop cures for diseases.
- ☐ Multiple transportation alternatives, including aerial tram, light rail, street car, bus, pedestrian, car and bicycle provide access.
- ☐ Thousands of new housing units are developed in conjunction with the creation of the campus.
- ☐ Campus design encourages rehabilitation of the river bank and restoration of endangered wildlife habitat in the middle of a growing urban setting.

The lessons learned during this process provide a valuable basis for other institutions and jurisdictions seeking sustainable development outcomes.

Introduction and Background:

Portland's South Waterfront, once an industrial center, is experiencing a regeneration as a vibrant, sustainable, mixed use district. A decades-long vision of urban renewal and infill

development on an industrial brownfield is finally coming to fruition. At the center of it all is Oregon Health and Sciences University (OHSU), acting as
the economic driver for the district while leading the discussion on sustainability and community building. The confluence of technologies, culture and leadership is ushering in a new era built around sustainability, design
and urban renewal.

The OHSU story is reflective of the pioneering and innovative spirit of Oregon. In 1887, the University of Oregon chartered a medical school less than 50 years after the opening of the Oregon Trail. The school of Dentistry, now housed in the Skourtes Tower at the Schnitzer Campus, was formed eleven years later. In 1917,
108 acres on Marquam Hill were donated and the medical school moved up to its current site on the hill two years later. The first hospital on the Marquam Campus opened its doors in 1923, contracting with the medical school to provide services to indignant patients. The next five decades saw tremendous growth with the opening of the first full service children's hospital in the Pacific Northwest, an outpatient clinic, a nursing program and a children's development and rehabilitation center. It was not until 1973 that the programs would merge into an integrated system of education, research and medical services.

OHSU sees around a quarter million patients a year, many of whom have the most challenging and complex conditions in the region, almost half coming from outside the Portland metropolitan area. OHSU schools host over 4000 students per year, attending many nationally ranked programs. A full third of all practicing Oregon MDs did at least part of their study at OHSU. OHSU functions as an economic driver of the state and the regional leader in biomedical research, a target industry for the City of Portland. 95% of research funding
comes from outside the state, bringing investment dollars to the regional economy. OHSU employs over 14,000 faculty, staff, researchers and support services, making it the largest employer with the city of Portland and one of the largest in the entire state. While a public corporation, the vast majority of OHSU operating income is derived from patient services, grants, gifts and contracts. In fact, less than 2% of OHSU's over $2 billion operating budget is derived from the state general fund. This translates into a return on investment of around
$100 in economic activity for every dollar spent of public money.

SUSTAINABILITY & PERFORMANCE STANDARDS

Global challenges - notably climate change, resource scarcity, and urbanization threaten the stability of life in metropolitan regions. For the first time in history, the majority of the world's population lives in cities, and these urban regions anticipate even greater growth. This population and resource concentration means that cities, and the institutions that comprise them, will increasingly be held accountable in addressing these challenges, compelling the exploration and adoption of urban sustainability practices and solutions. In light of these concerns, the following considerations have been integrated into this framework plan as a means to ensure expansion and growth with the lowest adverse impact possible on the environment and local ecosystems.

OHSU holds a vision for operations and expansion of its facilities portfolio in a manner that comprehensively balances the needs of the institution with protection of the environment and judicious use of natural resources. The Oregon Sustainability Act of 2006, Executive Order No. 06-02— Sustainability for the 21st Century, among other instruments, has shaped the establishment of policies, goals, and guidelines for OHSU facilities in the coming decades.

As the institution seeks to consolidate its operations and expand strategically onto the Schnitzer Campus, coordinated and consistent efforts will be made to make the highest and best use of existing facility assets while upgrading and expanding its holdings. The facilities master plan creates a framework around the somewhat opportunistic nature of expansion to help determine how these opportunities can be most beneficially realized. Within this context, scenario options for capitalizing on each opportunity need to be careful evaluated on a comparable basis. Additionally, broader partnering and shared infrastructure opportunities – many of them already under study – should be considered to leverage the investment.

CAMPUS LEVEL OPPORTUNITIES:

Make Efficient Use of Existing Assets in Fulfilling the Vision of the Facilities Master Plan.

Decisions regarding relocation of departments and expansion or renovation of existing facilities should be approached first with a view to the highest and best use of the existing facilities, including their renovation and expansion potential. New facility construction should be considered after realistic scenarios for reuse of existing buildings have been considered.

Investigate Sharing and Integration of Infrastructure Costs and Benefits with Partner Organizations.

The potential advantages of district-scale utility systems, as distinct from smaller-scale building-level and larger municipal-scale systems should be evaluated whenever possible. District-scale systems can offer both financial and resource-efficiency perspective opportunities not found in conventional systems. Partnering with private sector partners to achieve financing, ownership and operation, or a more balance demand profile should be examined as each opportunity arises. For example: the designation of the South Waterfront as an Eco-district
by the City of Portland holds potential for municipal support of shared systems on the South Waterfront Central Campus and the Schnitzer Campus. The distribution of residential occupancies with the institutional facilities on Marquam Hill suggests a favorable demand profile for district energy generation. Practical implications of such partnerships, such as their impact on entitlements and land use, will be considered carefully.

Create Responsible, Flexible, and Enduring New Buildings.

New buildings should be planned with adequate space and utilization rates to meet institutional growth projections. New buildings will also be designed for flexible, reconfigurable uses to the greatest extent feasible while maintaining budget and code compliance constraints. New and renovated facilities will be designed, constructed, and commissioned to the highest standards for environmentally responsive buildings, including usage of systems to reduce ventilation rate requirements without compromise to contamination or infection control; use of cascading recovery, harvesting and resource reuse strategies; and state-of-the-art low energy and low water use design. Additionally, buildings will be designed with consideration for potential

future additions, changes in use, and connection to district or shared utility infrastructure. Finally buildings will be constructed using best practices with respect to construction waste and site impact minimization.

Operate Buildings in a Comprehensive, Responsible, and Accountable Manner.

In addition to the current Facilities Cost Index maintained by OHSU, building operations will be reviewed for best practices. Tenant Improvement and other building-scale interventions will provide an opportunity to review and possibly, re-commission the facility for improved operation.

Locate Support Services Within Close Proximity to OHSU's Marquam Hill and Schnitzer Campuses

Over time, many OHSU support services have been relocated off of the Marquam Hill Campus to scattered owned and leased sites in downtown Portland and beyond. While moving back office and non-mission delivery programs and staff to less central locations frees up space on campus, the trend has created other inefficiencies and deleterious impacts. Employees often drive back and forth between their office and the Marquam Hill Campus to attend meetings and provide services. The increase in driving between these sites is a contributor to OHSU's growing carbon footprint. This master plan has identified the Central District near the lower Tram station as the ideal location to centralize support services. The location is in close proximity to both the Marquam Hill and Schnitzer Campuses which will be critical to serve all of OHSU as programs are relocated off of the hill. Further, the location leverages OHSU's significant investments in both the Tram and the
Portland Streetcar line that serves South Waterfront and will allow employees to avoid driving between these sites.

Policies and Practices

Energy Generation and Distribution

Stand-alone generation of building heating and cooling will be used on campus only in cases where centralized supply is not practical due either to limitations in capacity or distribution. Planning for the expansion and upgrade of generation and distribution infrastructure will continue and will be implemented as opportunities arise (see Strategic Energy Financing below).

Current plans include a replacement boiler plant on the site of the existing facility. The replacement plant will be designed to enable modular expansion of capacity and efficient, staged operation. Chiller plant capacity, in particular for the southern portion of the campus, will be augmented with a strategic plant addition. Distribution systems will be upgraded for capacity and performance with each phase of improvement. Chiller and boiler plants will be serviced at regular intervals throughout their service life.

Strategic Energy Financing

Means and methods for financing energy improvements on the OHSU campuses are currently under study. Third party ownership and financing, both of building efficiency improvements and systems infrastructure, is being investigated in the form of Energy Service

Company (ESCO) agreements and strategic plans with other interested parties.

District Energy Possibilities

The Portland Development Commission and OHSU commissioned a detailed study on the potential for district energy systems in the city-designated South Waterfront Eco-district. Third-party financing and other innovative mechanisms to capitalize, own, and operate the systems are under continued study. OHSU will remain party to the discussions as a potential participant in a district energy system either on the Schnitzer and Marquam Hill campuses.

Water Use and Management

OHSU published its *Comprehensive Stormwater Management Plan* in 2007. The study is the result of a Memorandum of Understanding between the institution and the City of Portland signed in 2004 to minimize and mitigate the impacts of storm water on municipal management systems in light of anticipated institutional development. The document follows closely the policies established in the 2005 *Portland Watershed Management Plan*. It describes a total of thirty storm water mitigation projects on the Marquam Hill Campus. Of these, twenty could be implemented without requiring professional design and engineering. These projects should be integrated into the implantation of the Facilities Master Plan. Additionally, a Storm Water Facilities Operations and Maintenance Policy should be developed to ensure sustained performance of these features.

Practices for the conservation of potable water have enabled considerable expansion of facilities with a concurrent reduction in overall potable water usage. Low-flow plumbing fixtures, automated flow control systems, and responsible design of water-consuming facility support systems will continue to improve the efficient use and conservation of potable water as the institution expands.

One notable exception to the general conservation-based approach to water systems on campus is the compressor cooling system, currently using municipally-supplied water. OHSU will create a plan to replace this water supply and implement it as part of the upcoming capital improvement plan.

Landscape

Local native ecosystems are threatened by invasive plant species on and near the Marquam Hill Campus. Control and management of these species will provide improved safe access for emergency vehicles, reduced catastrophic fire danger, improved aesthetics and begun restoration of the native forest on Marquam Hill.

Implementation of the *OHSU Invasive Plants Management Plan* was initiated in conjunction with students from Portland State University in 2010. The plan is intended to create a prioritized strategy to reduce risk from invasive plants before they cause greater harm. Specifically, the plan outlines steps to manage the issues in increments of time, with a projected level of required investment to achieve each step. OHSU has committed to completing and implementing the plan.

Solid Waste

Waste management plans at OHSU are the subject of ongoing review. Implementation of the LEED
certification system has assisted in improving recycling rates on a building-by-building basis.

OHSU will continue to investigate new technologies for on-site waste disposal and waste-to-energy (such as carbon-arc technologies) for implementation on the campus.

Transportation

The mode split at OHSU, particularly on the Marquam Hill campus, remains biased toward Single Occupancy Vehicles (SOV), which is unfavorable from and environmental as well as from a traffic and parking aspects. In order to encourage alternate transportation, OHSU will create a plan to for one or more bicycle centers, including showers, changing, and bike storage facilities, on its Marquam Hill campus. The plan will be included as a part of the overall capital improvements plan.

Building Performance & Certification Standards

All new construction at OHSU shall comply with the following criteria:

LEED for New Construction (NC):

http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220

Requirement: A minimum of LEED-NC Gold for non-patient-care new construction with the goal of achieving Platinum.

LABS21 ENVIRONMENTAL PERFORMANCE CRITERIA (EPC):

http://www.epa.gov/lab21gov/toolkit/epc.htm

Requirement: A minimum of LEED-NC Gold under the EPC system for research new construction with the goal of achieving Platinum.

LEED for Healthcare:

http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1765

Requirement: A minimum of LEED-HEALTHCARE Gold for patient-care new construction with a goal of achieving Platinum.

LEED for COMMERCIAL INTERIORS (CI):

http://www.usgbc.org/DisplayPage.aspx?CMSPageID=145

Requirement: Goal of LEED-CI Gold for all TI projects where the project scope includes a complete gut and remodel of the space and the size of the area exceeds 10,000 square feet..

LEED EXISTING BUILDINGS OPERATIONS & MAINTENANCE (EBOM):

http://www.usgbc.org/DisplayPage.aspx?CMSPageID=221

Requirement: Implement a policy to achieve LEED EBOM Gold certification for all OHSU-owned facilities by
December 31, 2015.

LEED 2010 Application Guide for Multiple Buildings and On-Campus Building Projects:

http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2326

Requirement: Create management and leadership to implement a campus-wide repository of LEED-related certification information.

SALMON SAFE

http://www.salmonsafe.org/

Action: Plan and budget for the construction of a refueling area cover as a part of the scope of a near-term capital project. Achieve the SalmonSafe certification by December 31, 2015.

SOUTH WATERFRONT HISTORY

For most of the 20th century, Portland's South Waterfront was a hub of industrial land use and activity, built on the accessibility of the Willamette River and nearby major rail lines. Today, the district is a center of transit oriented development (TOD) with modern mixed use towers and livable communities with a variety of amenities. This miraculous transformation is based on decades of vision and dedication by a number of individuals and organizations, including the long-term commitment of OHSU to create a dynamic and livable 21st century district.

At the beginning of the 20th century, businesses that relied upon the river for transport began operating in the South Waterfront, then known as South Portland. Early operations included manufacturers supporting the building trades and a burgeoning ship building industry. Access to haul roads and the railroad network provided access to resources for production as well as local and regional markets. Chemical manufacturers, metal fabricators and a trolley repair shop. During World War II, a marine industrial presence was established in the district. Many of these shipyards turned to scrapping after the war, dismantling and salvaging merchant and war ships. Secondary smelters and other salvage operations also set up shop while chemical manufacturers supplied agricultural interests in the fertile Willamette Valley with pesticides and fertilizers.

Early zoning in South Waterfront was largely "unrestricted" (1924 zoning code), later shifting to light manufacturing (1959), a designation only slightly more restrictive than the earliest forms of zoning in the city. In 1990, a city-wide overhaul of the zoning code shifted the allowable uses at the waterfront. The new designation, Central Commercial (CX), allowed most uses, including light industrial if the floor area was less than 10,000 square feet per business. However, CX zoning code does not allow freight, rail yards or warehouses, all of which are necessary for the viability of heavy industrial land use.

In 1966, completion of Interstate 5 reinforced a growing dependence on the automobile while isolating a district once sought out for its connections to downtown and beyond. The decline of rail and especially maritime traffic further disconnected the district from the rest of the city and the area began to fall into disrepair. Manufacturers went out of business or moved, leaving behind a legacy of soil contamination and industrial waste on largely vacant lands.

City leaders first integrated the South Waterfront into the planning dialogue in the late 1970's, envisioning a dense, livable neighborhood touted by growth management advocates and codified in the Oregon Planning System enacted by the passage of Senate Bill 100 in

1973. The Portland Development Commission purchased
73 acres of the district in 1978 with plans for integrating the new lands into the Downtown Urban Renewal Area. However, it would be another four decades before these first visions of a sustainable urban utopia would come to fruition in the form of a modern, mixed use district, built on the backs of collaboration, communication, trust and creative problem solving.

The Marquam Hill Plan

In the year 2000, the City began work on a Marquam Hill Plan to coordinate the future growth of OHSU with other planning efforts and the desire of the City to support and grow OHSU's three-tiered mission of patient care, education and research. At the time, OHSU was exploring opportunities for expansion in two areas: directly to the east in what is now the South Waterfront (then North Macadam) or further to the west in pro- growth municipalities of Washington County. The Plan and related background documents outline the constraints to growth and analyze the options for expansion of the three missions, including the critical functions of transportation and parking networks and open spaces.

OHSU planning processes determined that the Marquam Hill Campus was inadequate for the anticipated growth of the three mission based approaches, especially given the constraints of developing on a steep, forested
hillside accessible largely by one 2-lane road. Further reiterating this point was the limitations of parking on the hill. OHSU currently has only 0.7 parking stalls per 1000 square feet of development, well below demand of the 20,000 people that visit the campus each day.

The plan sets forth stringent guidelines for growth on the hill, essentially limiting OHSU to its current development footprint and necessitating expansion to another site. A number of limitations were put in place to reduce the impacts on surrounding neighborhoods, especially seeking to limit traffic increases on the limited capacity road system on the campus.

The need to expand was further emphasized by the wayfinding difficulties on the Marquam Hill Campus and the growth of outpatient services. Opening a new outpatient facility would open up hospital beds for severe and complex diagnoses and allow for easier access of patients needing less recuperation time or regularly scheduled visits. A new facility would further reduce the pressure to expand hospital services on the hill, a much more difficult prospect after the Marquam Hill Plan.

Once the decision was made to expand to the waterfront, analyses of transportation options commenced. The proximity of the waterfront to the Marquam Campus was a key factor in the decision. However, the isolation of the two locations meant that a rapid connection was needed to quickly move medical staff and patients between the two locations to retain the synergy of comprehensive patient care. OHSU decided on an aerial tram as the most viable option for rapid connectivity. The negotiation, planning and development of the aerial tram are described in a later section.

Development Agreement

On August 15, 2003, Portland City Council adopted the South Waterfront District Project Development Agreement. The agreement was inked in support of the South Waterfront Plan, an ambitious renewal of the 130-acre former industrial area. It was, and remains, the largest urban

renewal project ever undertaken in the city, leveraging public investments in infrastructure and in employment and education by OHSU to spur $2 billion in private development.

Despite decades of planning, public investment in the South Waterfront was stagnant until private interests stepped in. A number of investors, including OHSU, formed River Campus Investments, LLC, to begin purchasing lots in the central district of the SWF. Williams and Dame led the efforts, convinced of the potential for the site, despite overwhelming connectivity and environmental degradation issues. They recognized early on in the process that including OHSU as the centerpiece of employment in the district would drive the project forward and provide the new community with community based services and a much needed hub of activity. The redevelopment of the South Waterfront brownfield area would provide OHSU with the land base to expand its research, teaching and service facilities within the renewal area while acting as a catalyst for economic development and retaining jobs within the city. The PDS reports that "[W]hile the South Waterfront District represents less than 1 percent of the City of Portland's area, it is projected to 'assume 4.7 percent of the city's job growth, 2.5 percent of housing and residents and potentially more than 4.4 acres' of public open space."

The agreement took on a unique phased approach. Unlike many past urban renewal projects where phasing is dedicated to geographic areas, the South Waterfront vision called for incremental goals based upon infrastructure investment and development throughout the district. While this phased approach of strategically balancing public investments within a district wide vision was novel at the time, leveraging public infrastructure investments for private development is successfully and widely used for large-scale development projects across the country. The idea was to set the stage for private development by making the area development- ready.

The first phase set forth the prioritization of transportation infrastructure to improve site connectivity with downtown and surrounding neighborhoods. The large industrial lots were undeveloped, lacking public service infrastructure and roads and the district as a whole was disconnected from surrounding neighborhoods with limited access points. On top of roadway improvements, two key transportation projects. First, the city extended streetcar service to the central part of the district, connecting downtown with the South Waterfront. Streetcars were chosen for their aesthetic, functionality in dense urban settings and ability to drive economic development. Secondly, the aerial tram connecting OHSU's Marquam Campus with the South Waterfront was completed, a process discussed in the next section.

A second goal of the phase I public investment is the rehabilitation of the Willamette River and riverbank by creating public access and enhancing native vegetation and habitat. Oregon's Planning System calls out the Willamette Greenway as an area of special interest with improved public access and natural environment at the center of desired outcomes for the entire length of the river. As a former industrial site, the South Waterfront suffered from heavily contaminated soils and river sediments. The riverbank was an amalgamation of discarded concrete and metal scraps. The process of greenway development and rehabilitation is ongoing and the first stages of public bike and pedestrian trails are set to open within the next year.

The redevelopment of Portland's South Waterfront District was financed through a 20-year funding strategy established by the PDC. The basis of this strategy is a public-private partnership between the PDC and the key stakeholders.. This approach leverages public and private resources to generate investment and development in the plan area that would

otherwise not be feasible. Moreover, given the district's industrial heritage, public intervention was necessary to reduce the environmental and economic costs of development, and to encourage private investment in support of broader policy objectives. Public projects are administered and managed by the PDC. Approximately $131 million of the Phase I funds will be sourced through Tax Increment Financing (TIF), a funding mechanism that taps into the increased property values and associated incremental property tax increases from urban renewal projects to pay for urban renewal bonds. Another $23 million is coming from a variety of other public sources tied to specific improvements. For instance, much of the roadway development in the district is coming from the Portland Bureau of Transportation. The remaining gap is still under negotiation and coming from a variety of sources, including federal grants from the EPA, HUD and USDOT.

The Aerial Tram

Critical to the viability of expansion was the transportation linkages between the Marquam Campus and the South Waterfront. Access to the hill is restricted to only one 2-lane road that often backs up during rush hour. After exploring numerous options, leadership decided on an aerial tram, giving doctors, staff, students and patients direct access between the hill and the waterfront, and creating in the process a unified campus. The tram today is not only an iconic landmark in Portland, it is a study in the power of public-private partnerships and the importance of open communication. The aerial tram process was by far the most public and politically
contentious negotiation within the larger framework of the South Waterfront planning and development process.

The Center for Health and Healing

At the center of the South Waterfront renewal and leading OHSU and the entire healthcare industry into a new sustainable future is the highly regarded Center for Health and Healing (CHH). The 412,000 square foot building achieved double platinum LEED for New Construction through innovative green building techniques and integrated systems management. At the time, the largest medical facility to achieve LEED platinum, and indeed the first major medical center in the world to achieve such a high rating, CHH was designed to meet a number of challenges and opportunities facing OHSU while leading the institution into a new era of sustainability in design and in operations. The intersection of shifting patterns of patient care demand and the growth of new technologies allowing for less invasive procedures necessitated an outpatient focused building while the building's location at the South Waterfront central district allowed for a more accessible and comfortable experience for patients.

The 16-story building has eight levels devoted to physician practices, surgery and imaging, and three floors that house a health and wellness center. The wellness center features a gymnasium, four-lane lap pool, therapy pool, weight training and a day spa. Four levels are dedicated to education and research activities, including space for a biomedical engineering program. The ground floor houses retail space, including a pharmacy, optical shop and a café.

OHSU Master Planning

Master planning processes by OHSU supported the public-private development negotiations and aligned the visions for the district with the desired outcomes and implementation strategies of the development agreement. OHSU developed a 20 year master facilities plan, setting the stage for growth and expansion to the South Waterfront.

Basis of the Master Plan

MISSION, FOUNDATION AND GOVERNANCE

The purpose of the facilities master plan is to bring Oregon Health Sciences University (OHSU) facilities into congruence with its mission, which can be summarized as follows:

- ☐ Educate tomorrow's health professionals, scientists, engineers and managers in top-tier programs that prepare them for a lifetime of learning, leadership and contribution.
- ☐ Explore new basic, clinical and applied research frontiers in health and biomedical sciences, environmental and biomedical engineering and information sciences and translate these discoveries, wherever possible, into applications in the health and commercial sectors.
- ☐ Deliver excellence in health care and emphasize the creation and implementation of new knowledge and cutting-edge technologies.
- ☐ Lead and advocate for programs that improve health for all Oregonians, and extend OHSU's education, research and health care missions through community service, partnerships and outreach.

OHSU is the largest research institution in Oregon, with approximately 2,500 medical, dental, nursing, science and engineering, allied health students enrolled, and another 1,000 in training programs. OHSU employs approximately 14,000 people, making it the largest employer in Portland and the fourth largest in Oregon.

OHSU traces its origins to the University of Oregon Medical School, founded in 1887 and one of the oldest medical schools west of the Mississippi River. OHSU was established as a freestanding academic health sciences university in 1974 when the Oregon Legislature mandated the combination of the University of Oregon Medical School, University of Oregon School of Dentistry, and University of Oregon School of Nursing. When it was established, OHSU also included OHSU Hospital, Doernbecher Children's Hospital, and the Child Development and Rehabilitation Center. At that time, OHSU was one of eight units within the Oregon University System and was governed by the Oregon State Board of Higher Education. Since 1974, OHSU has grown to include several research institutes and smaller research and clinical centers, a number of allied health training programs, and a series of multi-disciplinary units.

In 1995, OHSU became an independent public corporation, and its governance became vested in the OHSU Board of Directors. As a public body, OHSU retains close ties to the State. The OHSU Board is appointed by the Governor and confirmed by the Senate. In

addition, that portion of the OHSU budget that comes from the state general fund appropriation must be submitted to the Legislature through a budget request to the State Department of Administrative Services, which is the same process as with public agency requests. OHSU's 116-acre main campus, the Marquam Hill campus, is located on the West Hills immediately south of downtown Portland. Most of the developable land, about 70 acres, has been developed. In 2002, OHSU, in collaboration with several other entities, purchased approximately eight acres near the Willamette River in Portland to be OHSU's next area of growth. Construction of the 400,000 square foot Center for Health and Healing was completed in 2006 on part of this land, known as the South Waterfront Central District, to house physician practices, outpatient surgery, a wellness center, research labs, and educational space. A streetcar provides transit service the area, and an aerial tram transports passengers to and from the top of Marquam Hill.

In 2004 the Schnitzer family donated a 19-acre parcel of riverside property that will allow OHSU to build a future education and research campus just north of the South Waterfront Central District. OHSU's School of Nursing also operates campuses in Ashland, Klamath Falls, Monmouth and LaGrande, Oregon.

PLANNING PROCESS

A sound planning process may be the most important part of any master planning exercise; without an inclusive approach to the collection of information and sharing of emerging ideas, consensus may be difficult to achieve. OHSU developed a comprehensive committee structure to provide continuity and campus-wide representation. The planning process included faculty, staff, administrators, and others.

The year-long planning process was divided into four major phases: Visioning, Framework + Scenarios, Resolution, and Documentation. The Visioning phase included data collection, interviews and meetings, physical analysis of existing conditions, and subsequent discussion of vision, goals, schedules and tasks. The Framework + Scenarios phase developed and reviewed possible scenarios and approaches for organizing campus programs with the various Steering Committees. The Resolution phase reviewed feedback from the prior phase and combined the best approaches into a preliminary plan and subsequently into a final plan. This portion of the process allowed users to test and refine specific recommendations of the plan

Vision

An optimally designed physical environment for health care, teaching and research is envisioned for each OHSU campus. The relationship between natural and built environments will differ significantly between campuses since they occupy fundamentally different places. On the Marquam Hill Campus, the vision is of a place conducive to thoughtful innovation in research as well as a place of health and healing. To achieve this, easy communication between co-dependent departments and activities must be achieved, suggesting careful re- assessment of proximity needs. Movement through the campus should be a pleasurable experience, drawing enjoyment from built spaces and open spaces alike, navigating with ease by day and after dark. Service and other vehicular movements should be designed for efficiency, yet impinge little on pedestrian circulation. Parking should be convenient yet inconspicuous. Campus access by means other than driving alone should predominate. The conspicuous virtues of the campus

should be capitalized upon fully: memorable views, the forest setting, and a heritage that includes some fine buildings.

A primary objective of the Master Plan is to provide a clear guide for OHSU site decisions and capital planning for each campus over the next twenty years. Master Plan recommendations must therefore be practical, fiscally sound, and sufficiently flexible to accommodate inevitable and unforeseeable changes. The vision presented in this master plan is one of progressive improvement and creation of facilities that will enable the institution to reach the new heights to which it aspires in health care, teaching and research. The Vision 2020 Strategic Plan puts a new emphasis on integration, collaboration, sustainability and accountability. These values underlie the vision and recommendations presented in this Master Plan. The vision is summarized in the project goals and guiding principles that follow.

Project Goals + Guiding Principles

Each of the five project goals that follow is expanded upon by principles that will guide design towards goal achievement.

GOAL 1: RECOMMENDATIONS OF THE MASTER PLAN MUST BE **ACHIEVABLE**.

Both physical and financial feasibility often depend on specific timing, and all must be aligned to make each project achievable. To this end, the facilities master plan must be aligned with business and strategic goals, and coupled to a realistic financing strategy; facilities improvements must be implementable with minimal disruption of other campus activities, and should be phased accordingly. Investments in facilities must be sustainable, so debt burden and operating costs must be carefully considered. Facilities investment decisions should be based on life-cycle costs rather than on initial capital costs.

GOAL 2: FUNCTIONS OF THE UNIVERSITY MUST BE FULLY **INTEGRATED** WITH ONE ANOTHER.

Each improvement must be consistent with OHSU's strategic overview, and must be coordinated with both existing and planned improvements. For example, coordination of functional adjacencies between facilities will foster collaboration between people and programs. In some instances, telecommunication will be sufficient to integrate efforts, in others, physical proximity will be necessary, and for some, impromptu face-to-face meetings may be important to stimulate interaction between programs and disciplines. The consequences of both collocation and separation of facilities should be considered, as should the potential of open space and informal gathering places to promote integration through interaction. The attributes of each potential site for a facility should be evaluated for its potential ability to further integration between programs and functions of the institution.

GOAL 3: THE MASTER PLAN MUST BE SUFFICIENTLY **FLEXIBLE** TO ACCOMMODATE CHANGE.

It is inevitable that unforeseen facilities needs will arise. To accommodate change, facilities planning, timing and design must be intrinsically flexible. Eventual adaptive reuse of buildings should be anticipated in the design of new structures, systems and spaces. The plan should be implementable through various phasing and sequencing scenarios. Consideration should be given to use of modular components that can be changed or upgraded with minimal disturbance to operations.

GOAL 4: THE MASTER PLAN MUST ACHIEVE **BALANCE** BETWEEN COMPETING INTERESTS. Each campus occupies a different physical setting, and must establish an appropriate relationship with its surroundings to enhance environmental sustainability, protect natural resources, and maintain harmony with neighbors while fully meeting program needs. In some instances, the internal program of a building may be at odds with its surroundings, and a balance must be found between internal and external demands. Such balance will depend on the contribution of each component of the campus: buildings, open spaces and other improvements; and each is to be designed with this balance in mind.

GOAL 5: CAMPUSES AND BUILDINGS MUST BE UNIVERSALLY **ACCESSIBLE.** The design of campus buildings and open spaces must of course satisfy the requirements of the Americans with Disabilities Act by removing barriers to physical access. Design should also enable easy navigation of the campus through clear sightlines, good signage and lighting, and creation of a series of distinct places around the campus. Priority should be given to safe and convenient circulation on foot by keeping vehicle routes separate from pedestrian ways wherever possible.

Organizing Themes & Constraints

SCHNITZER CAMPUS VISION

Primary organizing influences for the Schnitzer Campus framework plan are the size and configuration of the relatively flat 19 acre site, views across the river, and solar access. The orientation to east and south suggested by these is reinforced by the proximity of freeway structures to the north and west. The campus will form the northern terminus of the South Waterfront street system, and access will be primarily from Moody Street on the West or from the future light rail station on Porter Street which comprises the southern boundary of the campus. An unusual feature of the site is that the grade of all future public streets that bound the campus will be up to
14' above existing ground level. This presents the opportunity of locating building entries at this level with
parking or other uses below, and of sloping the site down towards the river.

The organizing theme of the framework plan is to arrange buildings in two ranks parallel to the river with a landscaped central street between them which is closed at the north by a building that masks the freeway structures of the Marquam Bridgehead. Functionally the theme is academic, bringing the three schools (Medicine, Dentistry, Nursing) from the Marquam Hill Campus together with the joint OHSU/OSU School of Pharmacy program and allied teaching programs offered in partnership with the Oregon University System.

Constraints to development of the Schnitzer Campus are the freeway structures to the north and west. Also the fixed entry points of Bond Street and River Parkway into the campus constrain the location of buildings and limit automobile access. Building siting is further constrained by the alignment of Moody Street to the west, and a greenway setback between River Parkway and the river on the east. Much of the existing ground level is at or below the hundred-year flood level, and any occupyable space must be at least two feet above that flood level. Another constraint which pertains primarily to the cost of construction concerns soil conditions. Most structures will require deep pilings, and in many locations, pilings will penetrate capped contaminated soils. Unlike the Marquam Hill Campus, there are no sensitive

land uses nearby other than the river and its closely regulated ecology.

SOUTH WATERFRONT CENTRAL DISTRICT

The theme of the South Waterfront Central District is landmark and major destination for pedestrians. It marks the intersection between the Marquam Hill Campus, to which it is connected by the aerial tram, and the Schnitzer Campus to which it is connected by Bond Street, Moody Street and the streetcar line. Though standing alone now, the landmark Center for Health & Healing building will eventually be linked to the Schnitzer Campus by a series of developed city blocks. It can be expected that the other OHSU owned blocks of the South Waterfront Central District will complement and reinforce the landmark character of the existing building, although its prominence from the freeway may be diminished by future development to the west.

The most striking constraint to the South Waterfront Central District is the grid of streets that define the square city blocks of which it is composed. These effectively determine the orientation and maximum footprint of building on each block. River views are limited by high-rise towers ranged along the Greenway, but upper floors of the existing building enjoy good views in all directions.

Campus Framework

The Campus Framework and Facilities Scenarios focus future investment on the Marquam, Central and Schnitzer Campuses, and are predicated by seven specific objectives. The objectives were derived from a series of meetings with OHSU faculty and senior staff, and represent a consensus among them on current priorities.

OBJECTIVES

1. Preserve development capacity on Marquam Hill for inpatient bed expansion.

2. Link building expansion directly with building disposition and backfill.

3. Implement the Schnitzer Campus Vision and plan for one new facility every five years in order to build out the campus in 30 years.

4. Preserve land in the Central District for ambulatory expansion and a support services building.

5. Integrate research activities in all campus sub-areas, and develop design guidelines to guide siting decisions.

6. Greatly reduce leased space costs by vacating the former OGI Campus in 2013 and all support service leases by 2017.

7. Seek opportunities for progressive “Campus Repair” on the Marquam Hill Campus by developing complementary relationships between buildings and adjacent open spaces, reinforcing safe and convenient circulation throughout the campus.

EXISTING SITE CONDITIONS

Location and Context

Each campus is shaped by its location, the configuration of its land, natural and manmade features, and by regulations that have governed its development. Thus, each of the OHSU campuses is distinct from the others in character and appearance, and in its potential to serve specific OHSU needs. The purpose of this chapter is to enumerate those factors that have shaped each campus as a prelude to understanding optimal use of each.

The University's original campus on Marquam Hill occupies the ridges and canyons of a rocky outcropping of Portland's West Hills. The steep terrain required access roads to wind up it, dividing its 116 acres into three groups of buildings, stepping down the hillside from north to south. Older buildings occupy the flattest sites, while more recent structures are fitted into variable topography and reconciled with established floor levels. Almost every viable site has now been developed, so that growth on the campus can only be achieved by displacing some uses elsewhere. For most displaced uses, new locations are planned on two sites on the west bank of the Willamette River.

The Central District comprises eight acres and six city blocks in Portland's South Waterfront District. The site is flat, with four blocks bounded by Gibbs Street, Curry Street, Moody Avenue and River Parkway. These blocks are unevenly quartered by Whitaker and Bond streets. Block 33 which is the equivalent of two additional city blocks and is bounded by Curry, Moody, Gaines, and Macadam Avenue. The Central District is currently occupied only by the Center for Health and Healing and its support facilities. It is connected to the Marquam Hill Campus by an aerial tram above Gibbs Street.

A quarter mile north of Central Campus is the 19-acre Schnitzer Campus, to which it is connected by Bond Street, Moody Street, River Parkway and the streetcar line. Most academic components of the Marquam Hill Campus are to be relocated into new, purpose designed buildings on the Schnitzer Campus. Now cleared of former industrial remnants, the Schnitzer Campus slopes gently towards the river from elevated streets along its south and west boundaries. Preferred views are eastward towards Mt. Hood across the broad Greenway that borders the river. These, and solar access to the south have shaped the framework development plan for this new campus.

Planning Context

CENTRAL DISTRICT PLANNING

By the 1990s, limits on growth on the Marquam Hill Campus were becoming acute, and OHSU relied more heavily on leased space nearby, conscious that the benefits of collegiality were largely lost in the process. The institution had long contemplated the corridor between Macadam Avenue and the Willamette, watching its steady conversion from industrial uses to a mix of commercial and residential development. Though physically close, a drive between waterfront and hilltop campus could take an unacceptably long time, and for many, ruled out the option of a satellite campus there. The idea of direct connection by aerial tram emerged from a study of transit options, and led to the acquisition of eight acres near the waterfront at

the foot of Gibbs Street, above which the tram would ride its cables.

A landmark building was conceived at the foot of the landmark aerial tram. The Center for Health and Healing was completed in 2006 giving OHSU a strong presence in the South Waterfront District adjacent to I-5. Functionally, this building would intercept large numbers of ambulant patients who would otherwise drive to the Marquam Hill Campus, using up scarce road capacity and parking resources. Futhermore, staff who work in both places could move between them in comfort taking only four minutes for the journey. An un-anticipated benefit of the tram was that many staff who had previously driven or taken transit to Marquam Hill now accessed Central campus, many via bicycle or streetcar, and rode the tram to their hilltop campus destinations, further relieving pressure on road capacity and campus parking.

SCHNITZER CAMPUS PLANNING

OHSU generated a compelling vision and development framework for the Schnitzer Campus in 2008. As envisioned, the campus will include all four of the University's schools and will provide a unique interdisciplinary environment for the education and training of health care professionals. The framework plan contemplates that development of the campus will be phased over the next two decades and will ultimately include over two million square feet in new education and research facilities. To guide detailed design and development of the campus, ten fundamental guidelines were stated:

A1-1.	Develop River Edge Variety
A1-2.	Incorporate Active Uses along the River
A4-1.	Integrate Ecological Concepts in Site and Development Design
A4-2.	Develop Successful Formal Open Areas
A5-1.	Consider South Waterfront's History and Special Qualities
B1-1.	Facilitate Transit Connections
B1-2	Enhance Accessway Transitions
B2-1	Incorporate Outdoor Lighting that Responds to Different Uses
C4-1	Develop Complementary Structured Parking
C13-1	Coordinate District Signs

Porter Street, which forms the south boundary of the campus, will connect downtown transit to a new transit bridge giving access to the east side of the Willamette. Light rail, buses and streetcars will all stop adjacent to the campus on Porter Street giving unprecedented access to the new campus from east and west. The new bridge will also give direct access to bicyclists and pedestrians from the east side of the river. Streetcars and local streets will also connect the Central Campus a quarter mile to the south.

FACILITIES MASTER PLAN

Vision

An optimally designed physical environment for health care, teaching and research is envisioned for each of the four OHSU campuses. The relationship between natural and built environments will differ significantly between campuses since they occupy fundamentally different places. On the Marquam Hill Campus, the vision is of a place conducive to thoughtful innovation in research as well as a place of health and healing. To achieve this, easy communication between co-dependent departments and activities must be achieved, suggesting careful re-assessment of proximity needs. Movement through each campus should be a pleasurable experience, drawing enjoyment from built spaces and open spaces alike, navigating with ease by day and after dark.

Service and other vehicular movements should be designed for efficiency, yet impinge little on pedestrian circulation. Parking should be convenient yet inconspicuous. Campus access by means other than driving alone should predominate. The conspicuous virtues of the campus should be capitalized upon fully: in the case of the Marquam Hill Campus, memorable views, the forest setting, and a heritage that includes some fine buildings.

A primary objective of the Master Plan is to provide a clear guide for OHSU site decisions and capital planning for each campus over the next twenty years. Master Plan recommendations must therefore be practical, fiscally sound, and sufficiently flexible to accommodate inevitable and unforeseeable changes. The vision presented in this master plan is one of progressive improvement and creation of facilities that will enable the institution to reach the new heights to which it aspires in health care, teaching and research. The Vision 2020 Strategic Plan puts a new emphasis on integration, collaboration, sustainability and accountability. These values underlie the vision and recommendations presented in this Master Plan. The vision is summarized in the project goals and guiding principles that follow.

Organizing Themes & Constraints

The organizing themes at each campus relate to natural setting, functional access, and the need for continuous change. Constraints relate to the size and configuration of each campus, the uses of adjacent properties, campus access, topography, geology, micro-climate and limitations imposed by development regulation. Themes and constraints affecting the planning of each campus may be summarized as follows.

SCHNITZER CAMPUS VISION

Primary organizing influences for the Schnitzer Campus framework plan are the size and configuration of the relatively flat 19 acre site, views across the river, and solar access. The orientation to east and south suggested by these is reinforced by the proximity of freeway structures to the north and west. The campus will form the northern terminus of the South Waterfront street system, and access will be primarily from Moody Street on the West or from the future light rail station on Porter Street which comprises the southern boundary of the campus. An unusual feature of the site is that the grade of all future public streets that bound the campus will be up to 14’ above existing ground level. This presents the opportunity of locating building entries at this level with parking or other uses below, and of sloping the site down towards the river.

The organizing theme of the framework plan is to arrange buildings in two ranks parallel to the river with a landscaped central street between them which is closed at the north by a building that masks the freeway structures of the Marquam Bridgehead. Functionally the theme is academic, bringing the three schools (Medicine, Dentistry, Nursing) from the Marquam Hill Campus together with the joint OHSU/OSU College of Pharmacy program and allied teaching programs offered in partnership with the Oregon University System.

Constraints to development of the Schnitzer Campus are the freeway structures to the north and west. Also the fixed entry points of Bond Street and River Parkway into the campus constrain the location of buildings and limit automobile access. Building siting is further constrained by the alignment of Moody Street to the west, and a greenway setback between River Parkway and the river on the east. Much of the existing ground level is at or below the hundred-year flood level, and any occupyable space must be at least two feet above that flood level. Another constraint which pertains primarily to the cost of construction concerns soil conditions. Most structures will require deep pilings, and in many locations, pilings will penetrate capped contaminated soils. Unlike the Marquam Hill Campus, there are no sensitive land uses nearby other than the river and its closely regulated ecology.

SOUTH WATERFRONT CENTRAL DISTRICT

The theme of the South Waterfront Central District is landmark and major destination for pedestrians. It marks the intersection between the Marquam Hill Campus, to which it is connected by the aerial tram, and the Schnitzer Campus to which it is connected by Bond Street, Moody Street and the streetcar line. Though standing alone now, the landmark Center for Health & Healing building will eventually be linked to the Schnitzer Campus by a series of developed city blocks. It can be expected that the other OHSU owned blocks of the South Waterfront Central District will complement and reinforce the landmark character of the existing building, although its prominence from the freeway may be diminished by future development to the west.

The most striking constraint to the South Waterfront Central District is the grid of streets that define the square city blocks of which it is composed. These effectively determine the orientation and maximum footprint of building on each block. River views are limited by high-rise towers ranged along the Greenway, but upper floors of the existing building enjoy good views in all directions.

ACADEMIC AND RESEARCH EXPANSION

The following three projects are consistent with the programmatic direction from the Academic and Research Steering Committee to implement the Schnitzer Campus Vision. These three buildings represent the first three phases of the new campus and development will being at the southwest corner of the campus and continue to the north along Moody Street.

If the three projects represent any change to the original Schnitzer Campus Vision, it is that they include more research space than the education focused campus proposed in 2007. The revised vision is for an integrated research and education campus with core research facilities that rival the research facilities on the Marquam Hill Campus. As mentioned in the previous chapter, one of the programmatic recommendations is to limit core research facilities to three locations: Marquam Hill, the Schnitzer Campus, and the ONPRC. This means that no additional research space will be added to the Central District due to the capital and operating

costs of supporting a fourth research core.

At the end of the first decade the new Schnitzer Campus will house the first two years of the School of Medicine's MD program, the Physician's Assistant and Radiation Therapy programs, the entire School of Dentistry, the joint OHSU/OSU College of Pharmacy program, PSU's basic Chemistry and Biology programs, and, potentially, a future School of Public Health jointly offered by OHSU and PSU.

1. OHSU/OUS Collaborative Life Sciences Building

   As the first phase of the new Schnitzer Campus, the OHSU/OUS Collaborative Life Sciences Building will set the standard and tone for future phases to follow. As such, careful attention and documentation must be made to ensure a coherent design approach that can be replicated in future phases. The project also represents the first physical manifestation of a strategic alliance between OHSU and the Oregon University System. The success or failure of this project will likely influence whether the two institutions partner on future projects.

   The Collaborative Building sits at the southwest corner of the Schnitzer Campus on the 90,000 sf block bounded to the west by SW Moody Street, to the north by future Meade Street, to the east by the future Campus Promenade, and to the south by the future Porter Street transit-way. The project will accommodate student growth in all of the programs that will relocate to the new building.

   - ☐ OHSU School of Medicine MD Program: 160 students per class year;
   - ☐ OHSU School of Dentistry DMD Program: 90 students per class year;
   - ☐ OHSU Physician's Assistant Program: 60 students per class year;
   - ☐ Radiation Therapy Program: 10 students per class year;
   - ☐ PSU Undergraduate Chemistry and Biology Programs: 500 –seat lecture hall and larger teaching labs to accommodate larger classes;
   - ☐ OSU/OHSU College of Pharmacy Phar.D. Program: 90 students for the third year in Portland; As currently proposed, the Collaborative Building program includes approximately 195,000 net assignable square feet and 275 parking spaces. In addition to the education programs, the building will house the research labs and offices for the OHSU Center for Spatial Systems Biomedicine (OCSSB). This new center is led by Dr. Joe Gray, the new Chair of OHSU's Biomedical Engineering Department who also has a joint appointment with the Knight Cancer Institute.

   The OHSU/OUS Collaborative Life Sciences Building is expected to be completed by the fall of 2013. At that time, the programs listed above will relocate to the new building. The spaces that these programs currently occupy on the Marquam Hill Campus and in CHH will be backfilled by other OHSU academic and research programs. Top priority for backfilling these spaces will be to relocate uses off of the OGI portion of the OHSU West Campus before that lease expires in December 2013.

2. Schnitzer Campus Building II

   The second building proposed for the Schnitzer Campus shares the same block as the OHSU/OUS Collaborative Life Sciences Building and will be seamlessly connected to that building at the parking and plinth levels. The program for building II includes the following elements:

   - ☐ The remaining School of Dentistry programs and services not already included in the Collaborative Building. Specifically, the dental clinic, administration space for faculty and the Dean, and the SOD research labs.
   - ☐ Up to 40,000 net assignable square feet of unassigned research labs to accommodate research program growth over the next five to seven years. Half of this research space may left in a shelled state rather than built-out when the building opens since it is intended to accommodate future research growth.
   - ☐ 200 additional parking spaces to be seamlessly integrated with the 275 parking spaces

   At this time, the total program space is estimated to be about 90,000 net assignable square feet, not including the parking areas. If this project is approved in the summer of 2011 then the building may be built at the same time as the Collaborative Building with a slightly delayed occupancy date of early 2014.

   Two site layout and massing options have been proposed for the second building on the Schnitzer Campus. The first option is a two tower scheme with Building II built on the north half of the block with a shared plinth that connects this phase to the Collaborative Building. The second option is for the Collaborative Building to sit on the entire block footprint with Building II built atop the northern half of the Collaborative Building. Both options are technically and operationally feasible.

3. Schnitzer Campus Building III

   The final academic and research facility proposed during the first decade of the Facilities Master Plan is a third phase of the OHSU Schnitzer Campus. This building is proposed to be located on the site adjacent to Building II and immediately north of future Meade Street. This block is intended to accommodate two buildings and Building III must be designed to accommodate a second building on the site. The program for Building III is less detailed at this time, but it is envisioned as a research building that could accommodate the Center of Emphasis growth of the Knight Cancer Institute.

   Schnitzer Campus Buildings II and III should be designed to accommodate connections below future Meade Street. The City of Portland prohibits above grade crossings of public streets (i.e. sky bridges). Therefore, it makes sense to anticipate a future connection below Meade Street to allow researchers in Building III to access research space and core facilities in the Collaborative Building and Building II.

4. Schnitzer Campus Buildings IV & V

The direction from the Academic and Research Steering Committee is to plan for a new building on the Schnitzer Campus every five years so the campus is fully built-out over 30

years. Accordingly, the second decade of this scenario proposes two additional building on the new campus: Schnitzer Campus Buildings IV and V. At this time, no specific program for these buildings has been committed to, but the following options should be evaluated:

- ☐ OHSU School of Nursing;
- ☐ OHSU/PSU School of Public Health (if not already accommodated in Building III);
- ☐ School of Medicine Master's Degree Programs;
- ☐ Allied Health Programs (those programs not already included in Building I);
- ☐ Academic and Student Affairs;
- ☐ The offices of the Deans and Provost.

Schnitzer Campus Building IV will share the same block as Building III which is bounded by SW Moody Street to the west, future Arthur Street to the North, the future Promenade to the east, and future Meade Street to the south. Schnitzer Campus Building V is located across Arthur Street and immediately to the north of Building.

AUTHOR/PRESENTER BIOGRAPHY:

Mark B. Williams is Vice President for Campus Development at Oregon Health & Science University (OHSU) in Portland, Oregon, USA. OHSU is Oregon's only academic medical health center, serving the State of Oregon, Southwest Washington, and beyond. At OHSU Mark is responsible for all campus planning, design and construction activities, along with real estate transactions. Mark also was the founding Chief Operating Officer for the Vaccine and Gene Therapy Institute of Florida, an OHSU-affiliated research institute focusing on human immunology. Mark has also served as Chief Operating Officer for Metro, the Portland, Oregon area regional government and planning authority, as General Manager for MERC, Portland's public spectator facility management organization, and as a Tribal Court Judge for the Confederated Tribes of Siletz Indians, an Oregon based Indian Tribe recognized by the United States Government. Mark is an attorney with experience in business transactions, government law, civil litigation, employment law and the laws concerning Native Americans and Tribal Governments. He earned his Bachelor's degree from Rutgers University and his law degree from the University of Oregon.

RECYCLING OF USED LUBRICATION OIL AS A METHOD OF ENVIRONMENTAL POLLUTION CONTROL AND ENERGY RESOURCES CONSERVATION

BY

DR. AWUZIE CHIOMA IRENE
RENEWABLE ENERGY RESEARCH AND DEVELOPMENT UNIT
FEDERAL POLYTECHNIC OKO
ANAMBRA STATE, NIGERIA

E MAIL: alwayschioma4sure@yahoo.com

ABSTRACT

In this paper, reusing of waste lubrication oil while keeping the basic characteristics of a fresh Lube is examined. Used lubrication oils are one of the greatest source of pollution worldwide mainly because of the quantity generated, their high toxicity level and mostly because of their mismanagement. The oil consumed can be a great source of contamination if it is thrown as a waste or can be consideration as a new source of energy if properly used, and all depends on methods of how used lubrication oil can be reused. The oil wastes were collected from Lube bay, mechanic workshops, and factories and recycled using activated charcoal/clay treatment method. The parameters tested on recycled lubrication oil are flash point, pour point, specific gravity, metal contents, viscosity and Sulphur dioxide (SO_2). The results of these variables on the quality of product are high and the possibility of restoring two-third of the oil consumed is proved in this research.

Key words: Waste oil, base oil, and environmental pollution

INTRODUCTION

Lubricating oil is a valuable and essential product obtained from petroleum fraction consists essentially of complex mixtures of hydrocarbon molecules. They are mostly composed of isoalkanes having slightly longer branches and the monocycloalkanes and monoaromatics, which have several branches on the ring (Cutler 2009). These hydrocarbon molecules generally range from low viscosity oils having molecular weights as low as 250, up to very viscous lubricants with molecular weight as high as 1000. The carbon atoms range from 30 to 34(Concawe, 1985).

Lubricating oils are viscous liquid used in various production machineries, power plants, automobile and other moving parts of engines and machines for reducing friction, carrying away heat, protecting against rust, wear and sealing out contaminant. Further build up of temperature degrade the lubricating oils, thus leading to reduction in properties, such as viscosity, specific gravity, cloud point, pour point and flash point. Among other properties, viscosity index (VI) is the most important of all the properties of lubricating oil. It is a measure of the rate of change of viscosity with temperature. The smaller the change in viscosity with temperature, the higher is the viscosity index and vice versa. Therefore, high viscosity index oils are good quality oils for use in engine crankcase. Extraneous impurities enter from the surrounding air and from the machine on which the lubricant is being used. These are: dust, dirt, moisture, metallic particle, carbonaceous particles, and unburned fuel. These contaminants affect the life and efficiency of the device being lubricated as well as the life of the lubricant. Dirt and metal parts worn out from the surfaces are deposited into the lubricating oils. With increased time of usage, the lubricating oil loses its lubricating properties as a result of over-reduction of desired properties, and thus must be evacuated and a fresh one replaced.

Large and increasing volumes of lubricating oil are produced each year that after use, are considered hazardous waste. This is so because waste oils typically consist of a mixture of undegraded base oil and additives with high concentration of metals, varnish, gum and other asphaltic compounds coming from overlay on bearing surfaces and degradation of the fresh lubricant components. With the large amount of lubricating oils used the disposal of used lubricating oils has now become a major management problem. Many countries are now addressing the problem of environmental pollution posed by used lubricating oils. This has led industries and governments to find environmentally friendly solutions that will reduce the contribution of used lubricating oil to pollution and also recover these valuable hydrocarbon resources (Cooke 1992).

In disposing used lubricating oil, many used it as a dust cure; that is for dust prevention (Bennet et al, 1980). This method of disposal is in many ways unsatisfactory as the lead-bearing dust and run-off constitute air and water pollution. Incineration is another method by which used lubricating oil is disposed. This method is another unsatisfactory use of such a valuable product, with resultant emission of probably carcinogenous products that contributes to environmental pollution (Georgel and La Tour 1997). Both of these practices lead to non-end environmental problems, whether through the smoke of furnaces, the content of soot, toxic metals or contamination of surface water source and underground. In extreme cases, these contaminants damage furnaces, thus leading to increase environmental pollution (Kajdas, 2000). Emission of zinc (Zn) can be as high as 600 times and copper (Cu) can be 2100 times if waste oil is burnt instead or re-refining (Boughton and Horvath, 2004). It is a fact that four liters of oil is able to contaminate four million liters of drinking water and can form a thin layer oil on the surface of

the water which prevents oxygen from being dissolve in water, which hampers all kinds of aquatic life and the processes of photosynthesis as indicated in Rahman et al (2008) and in Boughton and Horvath (2004).

Recycling of used lubricants is now attracting more attention than before, this is partly because of the fear of dwindling of world oil reserves and more as a result of the environment concern which it posses. On the other hand, this vast amount of waste petroleum fraction can be considered as a very valuable source of energy, and could be beneficial for the country both economically and environmentally. If thrown as waste, the used lubricating oil will be a major source of pollution and the loss of an essential resource for the production of base oil. It is largely due to this, that conservation of petroleum resources has been declared national policy for several countries and the benefits of wise resource management are obvious. Recent impetus on waste recovery leads to renewed interest in re-distilling to converting of used lubricating oil into useful fresh lubricating oils. Re-distilling or refining is the use of distilling and refining processes on used lubrication oil to produce high quality base stock for lubricants or other petroleum products (Mortier and Orszulik, 1994).

This current investigation aims at regenerating base oil from used lubricating oil which was collected from different places and different sources, blending to specification to obtain a fresh "lube", thereby reducing environmental pollution and also minimizing importation of lubricating oil.

BASIC CHARACTERISTICS OF LUBRICATING OILS

Viscosity Index: - is defined as the force acting on a unit area where the velocity gradient is equal at a given density of the fluid. Viscosity is strongly depending on the temperature. With increasing temperature, the viscosity has to be stated for a certain temperature. Lubrication oils are identified by Society of Automotive Engineers (SAE) number. The SAE viscosity numbers are used by most automotive equipment manufacturers to describe the viscosity of the oil they recommend for use in their products. The greater or high the SAE viscosity numbers, the more viscous or heavier is the lubricating oil (Scapin 2007).

Specific Gravity: - is the ratio of the density of the material to density of the equal volume of water. From theory, density of a body substance is equal to the mass of a substance divided by the volume of the substance.

Pour Point: - is a measure of the temperature at which the oil ceases to flow under service condition of a specific system.

Cloud Point: - is the temperature at which paraffinic wax and other oil is cooled under a given condition.

Flash Point: - is the minimum temperature at which an oil gives off sufficient vapours to form an explosive mixture with air. The flash point test gives an indication of the presence of volatile compounds in oil and is the temperature to which the oil must be heated under specific conditions to give off sufficient vapour to form a flammable mixture with air. There are various methods of determining flash point of oils as contained in ASTM (Art, 2010).

Water Content: - In almost all system, traces of water in the lubricant are unavoidable, arising from such sources as leaking oil cooler, engine cooling system leaks and from atmospheric condensation. Accordingly, the water content must not exceed the "action" levels (more than 0.5) recommended for the different grades of oil and application. The presence of excessive water contamination will affect the viscosity of the oil and this may give rise to emulsion formation and can also lead to gear tooth and bearing problems.

MATERIALS AND METHODS

Apparatus
Measuring cylinder (500ml), Beaker, Round bottom flask, Erlenmeyer flask (250ml)
Distillation Column, Separating funnels (500ml), Filtering flask, Buchner funnel, Thermometer (360^{o}C), Flash point tester.

Equipment
Atomic absorption spectrophotometer (AAS), Sulphur content analyzer, Coiled Condenser, Whatman filter paper (No I)

Sampling
Samples of used oil were collected from different sources and a variety of oil, including lubrication of vehicles and machines in the workshops and places of various industries in towns in Anambra state. These oils were then mixed together to form a complete sample representing the different types of waste oil.

Experimental Procedure
The procedure for the purification of the used lubricating oil consists of filtration and sedimentation before subjecting to activated charcoal/clay treatment method. Solid particles and water in used oil were removed by gravity sedimentation. Two layers were formed and the top was used oil. This used oil was collected. The used lubricating oil was filtered to remove impurities such as dust, sand, metal chips and particles that are contained in the lube base oil. This was done using a funnel with a filter paper (Whatman No 1) place in it, then a vacuum pump was connected to the filtering flask to which the funnel was fixed with the aid of a rubber stopper. 4Litres of the used lube oil were filtered, stirred thoroughly to provide homogeneity, from the stock 450ml was measured out and transferred to a 500ml beaker and 150ml of gasoline was also measured and added to the used oil. The base oil mixture was transferred to the bucket of the centrifuge and centrifuged at 1500rpm for 5 minutes. And left to settle for another 20 minutes before decanting into a beaker. The decanted liquid mixture was distilled to remove water, gasoline and any other liquid that may be present. The content in the flask was cooled, stirred for homogeneity and 200ml used lube oil was measured into a separating funnel containing 100ml of ethyl acetate. The solution was left at room temperature for 24hrs. After decanting from the paste, the solution was treated with clay and activated charcoal. Filtration and evaporation was carried out under reduced pressure.

CHARACTERISTIC TESTS

Viscosity: The fresh oil and the used lubricating oil were heated one after the other to attain a temperature of 100^{o}C. The bulb of the clean viscometer was then filled with the hot oil (at 100^{o}C to the mark while immersed in a thermostat.

Specific Gravity: This was measured using the hydrometer. The density was observed at 60^{o}C and the value recorded.

Flash Point: 10ml of the re-refined lubricating oil was introduced into a 100ml beaker and then a thermometer inserted. The beaker was placed on a bursen burner and flame was brought at intervals to determine the temperature at which a flash appears on the surface of the sample while the lube oil in the beaker was heated.

Pour Point: 20ml of the lube oil sample was introduced into a plastic container. The lube oil sample was chilled at the rate a paraffin wax will begin to solidify and separate out in crystalline form. The temperature at which this occurs is known as cloud point further chilling was continued until the lube oil stop to flow and the temperature this occurred is pour point temperature was recorded.

Sulphur: 1ml of the lube oil was introduced into a burette and attached to the spectrophotometer clip; when this position is achieved, the radiation source is allowed to emit its rays from x-ray tube. The excitation effect is proportional to the concentration of sulphur in the sample.

Iron (Fe): Metal content was determined using the atomic absorption spectrophotometer (AAS). Sample containing the metal to be analyzed was digested. The cathode lamp for iron (Fe) was put in position and the characteristic wavelength selected using wavelength selector; standard solution of the element was first prepared and their absorbency measure at (327.7nm) wavelength.

RESULTS AND DISCUSSION

The base oil was collected analyzed and compared with ASTM standard to determine the different properties of the base-oil. The characteristics of used oil and the regenerated base oil are shown in Table I.

Table: I Results of Tests

Parameter	Fresh lube oil	Used Lube Oil	Activated charcoal/clay treatment
Viscosity index	92.50	21.10	87.50
Specific gravity at 60^{o}C	0.90	0.91	0.88
Flash Point ^{o}C	188.00	120.00	175.00
Pour point	-9.00	-35.00	-12.00
Sulphur	-	0.80	0.045
Iron (Fe) ppm	-	22.50	7.50

The activated charcoal/clay treatment process was conducted under the atmospheric pressure and the aim was to make the oil free of oxidized polar compounds, acidic products additives and suspended particles and also, to keep the hydrocarbon families in the oil unmodified.

The pour point of the oil generated was determined -12.00 and it did not affect the operational variables. The flash point of fresh lubricating oil is 188^{o}C while that obtained using activated charcoal/clay is 175^{o}C. The flash points of these oils are 188^{o}C for fresh oil, 120^{o}C for used oil and 175^{o}C for activated charcoal/clay treatment. The decrease in value of flash point for the used oil could be as a result of the presence of light ends of oils (Rincon, 2005). In essence, after undergoing combustion and oxidation at high temperature of the combustion engine, the oil breaks down into components parts, which include some light ends.
The result of the viscosity test shows that, the used lube oil has lost most of its viscosity 21.10 due to contamination. However, treatment has restored most of its viscosity to 87.50. In general, oil is considered unfit for service if the original viscosity increases or decreases to the next SAE number. Viscosity increase can occur due to oxidation or contamination (Scapin 2007).

The specific gravity for the fresh and used lubricating oils is 0.90 and 0.91 respectively, while the re-refined oil obtained by activated charcoal/clay is 0.88. The specific gravity of the contaminated oil could be lower or higher than that of it fresh lube oil depending on the type of contamination (Chevron lubricating oil ISO 100).

The sulphur content of used lube oil 0.80 while the re-refined is 0.045 is high, this is due to the presence of wear caused between moving parts. Corrosion of engine is caused by mineral acids formed by the oxidation of sulphur compounds in fuel in internal combustion engines with refined oils; those hydrocarbons that were inherently unstable will have been oxidized during use (Rincon, 2005).

The level of metal (Fe) in used lube oil 22.50ppm and activated charcoal/clay regenerated oil is 7.50ppm. Most engine block is made of iron, hence during combustion of fuel in the engine chamber the wear of this metal in parts per million (ppm) is found in the used oil. The wear of this metal is due to the corrosion caused by the presence of water and aided by fuel dilution due to bad piston and rings (Art 2010).

CONCLUSION

The total country's assumption of lubricating oil is more than 200,000ton per year and approximately 200,000 tonnes of waste oil is generated. Most of oil is either disposed to the environment or burnt improperly, contributing significant adverse effect to the environment. Proper collection and regeneration of waste oil can be beneficial by, **1.** Reducing environmental pollution, **2.** Saving foreign exchange for importing fresh lube oils and, **3.** Conserving of mineral resources. This is because to produce four litres of base oil, which is environmentally friendly, four litres of waste oil is needed which is considered as a source of contamination to the environment. Regeneration of waste oil and associated product markets should be patronized by us all, government inclusive.

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RESPONSIBLE ORGANIZATIONS – CONSTRUTING AN IMAGE OR REAL CONCERN?

Elsa Máximo

The Social Responsibility actions are becoming a powerful competitive advantage in business development organizations, as consumers value the business concern to make the society more balanced, with less injustice and inequality.

The concept of Corporate Social Responsibility has been consolidating itself as an interdisciplinary, multidimensional and associated with a systemic approach, focused on the relations between the public, directly or indirectly linked to the business initiative. Thus, it is essential to their incorporation into the strategic direction of the company, reflected on ethical challenges to economic, environmental and social dimensions of business.

In short, being a responsible company means to exercise their social, role externally and internally, with the aim of achieving a fairer society and to promote human development.

"Can not stress enough that corporate support is now a key component of modern management."

Key words: Corporate Social Responsibility, Sustainability, Responsible Organizations.

Communication is often understood by sociologists, by the Public Relations Professional and by politicians as the predominant mode for the creation and the development of social ties. Nowadays the role of communication is not some haphazard manner, the information conveyed by the mass media and the new media represent a significant portion of the thousands of messages that circulate daily in society. With the mass media and the new media Organizations face a new world, the world of global communication. The speed at, which messages, are conveyed in new messages of different faiths and cultures, located in various parts of the planet, makes the emerging need for "good build" what organizations communicate in controlled and uncontrolled way.

The informal and cultural globalization is undoubtedly a way to set aside the traditional concepts of space and time, thus forming a new concept of society: The information society.

This new concept leads civilizations and cultures have to communicate with each other with increasing frequency, with greater intensity, making the common communication between them. With this emergency, communication lost the traditional way of unidirectional communication and appears the dynamic bilateral communication, allowing publics heard their voices for validation or disagreement of content delivered by the organizations.

"If exact match exists, point by point, among physical symbols and mental concepts, there were no faults in human communication. Men could understand one another as if they read their own minds"

Syntopican – Great Books

As we are dealing with an open system, it is often exist undesirable disturbances, which could mean for organizations failed Reputation or negative image, changing the social perception has its stakeholders, changing the way the image of this organization shall be occur perceived.
The choice of topics or content to be disseminated, and the positioning of the Mission and Vision of the organizations, their way of acting and to convey to their public, have to possess consistency and proper structuring the management of organizations. The communication of CSR and Corporate Communication must be matched so that the organization has only one Global Image and aligned, combined with a clear and understandable to all stakeholders communication. The non-verbal communication "acts" of organizations is full of symbolism and meanings, transmits simultaneous beliefs and values that may be common or disparate with their public.

A well structured, solid organizational culture is key to creating a organization Image, promoting the real differentiation from other, and consequently getting success.
Increasingly, organizations are required to ensure their competitiveness by creating internal mechanisms sufficiently structured to lead to the emergence of strong powers of differentiation. Since communication is the way the organization will make your goals achievable in the market, getting "license" of stakeholders to act, you have to verify responsiveness between both fostering strategies, acting in accordance with the interests of its key stakeholders. Taking advantage of the current consciousness of these to give them the desired image of CSR and Sustainability, namely respect for local communities.

RESPONSIBLE ORGANIZATIONS : CONSTRUTING AN IMAGE? REAL CONCERN?

Why use the expression Constructing Image instead of Building Image?
When an organization thinks about it´s image does not think of it as something imaginary, intangible, thinks rather as something that touches you feel, what you see without witness of designing ideas and concepts.
That he may do it this way, should take into account structural concepts of communication and design of image strongly disseminated throughout the world by means of the biggest names of the major theories of Marketing of Management and Communication.
Globalization, with the existing communication networks, with social networks, the flow of information is unstoppable, how quickly a news whether it be good or bad news spreads through the whole world by blogging lets organizations in constant alert about all your steps. What Organization's communicate it's a constant careful, how communicate, where it communicates.
The communication of an organization is not controlled by all his channels, and this communication uncontrolled influence very consistently the views of their audiences, this uncontrolled communication can destroy in a few hours the work of an entire "life" of the organization.

Three concepts have been developed significantly on this XXI century:
• Corporate social responsibility;
• Sustainability;
• Picture or corporate communication

WHAT IS THE "ORGANIZATION IMAGE"
HOW TO BUILD THE "IMAGE"; HOW TO KEEP A "IMAGE";
HOW TO CALL ATTENTION OF THE PUBLIC TO THE "IMAGE" OF THE ORGANIZATION

The perception that people have of your business when they hear your company name. A business's image is composed of an infinite variety of facts, events, personal histories, advertising and goals that work together to make an impression on the public.

Currently, in the business sphere there is a perception that a company's success and the benefits for agents that move around these, depends not only on short-term profit, but much more political and socially coherent and responsible behavior. Never forgetting the interests of their customers, who treated well, contributing to the main reason for the existence of enterprises.

The company as a corporate member became a part of society and has obligations to perform the common good are not exhausted in law enforcement and the timely payment of taxes and contributions. Therefore, the similarity of Quality Management, Social Responsibility and sustainability policies of an enterprise should be considered an investment, not a cost. This social approach embodied in other long-term strategies minimizes risks and unknowns, causing permission to act, or CSR as an ongoing process, have to add something to what is required by law in the different dimensions that integrate CSR - internally and outside. Employees realize that working for a company that cares about the welfare and where they can extend their citizenship. Employees benefit from the social actions of the company, and especially those who participate in them, are more motivated, improve their performance, adhering to the company's programs. It is

logical that have motivated employees who wear the shirt of the company, is an important source of competitive advantage, these days.

Good corporate image does not relieve the company of commentary negative, but helps rescue it and save time and money. If your organization has credibility, even if the company is guilty or accused of misconduct or omission, will find more tolerance on the part of public and media

When social activities are properly targeted, ensure any organization a prominent position in society where it operates. Audit processes the image of organizations allows them in near real time to adjust communication strategies, evaluate the performance of these, either internally or externally, recognizing their strengths and weaknesses.
The positive public image with, that organizations intensivelly pursue and aspire, is not built exclusively by its controlled system of communication. Arises from own history, culture and social responsibility with the various stakeholders.

No company is going to have good image if it does not know to manage their processes in a socially responsible way.
The Image is what the organization wants to convey to their audiences, is the shadow of his identity. the clearer it is more coherence conveys to their goals, behavior and actions, allowing you to achieve the image that aims more easily. It is a big challenge for organizations reconcile their identity with their visibility. The visibility is going to understand the various external manifestations that make visible and perceptible organization before the public sometimes does not meet the organization's identity. Most often the problem is not in the information provided, but how it is communicated to the public, the way you communicate can influence how the message is decoded very negatively.
There are numerous tools that organizations can use to define and to improve its image before various audiences receive it. In today´s world there are still large social differences, high financial, food, health needs, paving companies a vast field of work and contributions to capital gains true for populations, this type of action, and in still worked properly, allow you to create, maintain or improve the image of organizations.

On the positive side, we can say that CSR is a good marketing tool for organizations to enhance reputation, attract customers, and sell himself as a great place to work.

FASHION ? REAL CONCERN? IMAGE?

The management of natural resources and environmental impact - reducing the overexploitation of resources, emissions and waste production is, in the case of multinational companies to their integration, crucial to their success. Thus, seeking to capitalize on the traditions and strengths of the local environment. The reputation and image are essential to their competitiveness and global environmental concerns, since environmental problems are of a global nature, going beyond borders, companies should be concerned about the effects that their activity may cause to the environment. For these reasons, companies and communities are responsible for the conscious consumer, ie the use of goods and services that meet basic needs and bring a better quality of life for the people and at the same time, minimize the use of resources natural, toxic materials and emission of pollutants, so as not to harm future generations.

CSR

"*CSR is the continuing commitment by business to maintain ethical behavior and contribute to economic development while improving the quality of life of employees and their families, the community in which they work and the community at large*"

World Business Council for Sustainable Development

The CSR arises when "companies decide voluntarily to contribute to a better society and a cleaner environment" and "Being socially responsible means not only the fulfillment of all legal obligations - but also going beyond through increased investment in human capital, the environment and the relations with stakeholders and local communities "

Green Paper of the European Commission

In July 2001, the European Commission has defined CSR as an optional and spontaneous incorporation of social and environmental concerns in the interaction of companies with stakeholders aimed at sustainability, saying in practical terms in the internal and external relations firms.

The main function of an organization image is to create value through producing goods and services that society demands, thereby generating profit for its owners and shareholders, and well-being of society through job creation.
But the emergence of new social and market pressures are driving the changes in values and horizon of business activity.

The socioeconomic transformations in the last 20 years have profoundly affected the behavior of firms who were accustomed to the exclusive profit increase without having premised devolution in social actions, ie the practice of social responsibility, as stated by Cohen (2000). If on one hand the private sector has increasingly prominent place in creating wealth, on the other hand, it is well known that with great power comes great responsibility. Depending on the existing creative ability, and now the available financial and human resources, companies have an intrinsic social responsibility. (Cohen, 2000, p. 102). The idea of corporate social responsibility in business is therefore recent. With the emergence of new demands and pressure, for greater transparency in business, companies are forced to adopt a more responsible attitude in their actions. Unfortunately, many still confuse the concept with philanthropy, but the reasons behind this paradigm does not concern only the social welfare, but also involve better business performance and higher profitability.

The pursuit of corporate social responsibility has, predominantly, the following premise, according Alencastro (2002-2):

> " [...] *Companies must not only fulfilled its shareholders. Quite the contrary. The market should now be accountable to officials, the media, the government, non-governmental and environmental sector and, finally, to the communities in which it operates. "*

In summary, the author explains that companies only gain the inclusion of new social partners in their decision-making processes and a more participative dialogue, not only represents a change in company behavior, but it also means greater social legitimacy.

Corporate social responsibility means to understand and to act in response to that new demand of the society. The value generated by a company is reflected in benefits not only for its shareholders,

but also the environment and the community (employees and the remaining of the society), respecting its culture and acting in an ethical and transparent way.

Social responsibility is more than paying taxes and enforce laws. This is a relatively recent concept, consisting act in an ethical and responsible towards the community in which the company operates attitude, focusing on the concept of active and responsible citizenship.

The Social Responsibility actions are becoming a powerful competitive advantage in business development organizations, as consumers value the business concern to make the society more balanced, with less injustice and inequality. Clear that companies now have an important social role in creating jobs and stimulating economic development, but there is very more that can be done to benefit the community, helping to create a better society. And the advantages of being a company socially "Conscious" are not just for others but for the organization itself.

- More prestige. A socially responsible stance has immediate effects on an organization's reputation. Greater prestige also means greater confidence in the company and the respect of consumers and the general public, enhancing the ability to attract and retain customers;
- Higher appeal for job seekers and also higher engagement by employees through fundraising activities and volunteering;
- Improved relations with the community. Working for social development, the company automatically becomes more known in the community in which it operates and to integrate better into the environment in which it operates;
- Advertising. This type of action easily captures the interest of the media, which brings more notoriety to the company. The disclosure of social role of an organization is, nowadays, most of the factors that influences public opinion, also reducing the risk of advertising negative;
- New business opportunities. The involvement in different types of projects and areas of activity allows relate to other companies, which may culminate in the birth of interesting strategic partnerships;
- Motivation and productivity. Being part of an organization that cares about the welfare and promotes equality and justice are always a reason for pride for any employee. Quickly, this sense of responsibility is instilled in own human resources company;
- Improved external image. Social and environmental issues are key concerns in all EU countries. Thus, the manifestation of a social conscience and responsibility in your company helps more visibility across borders, facilitating potential relationships internationally;
- Performance. In general, all factors associated with social responsibility positively influence the performance of the company and are a factor of proven growth;
- Strong reputation and corporate image among all stakeholders;
- Brand differentiation by showing different ethical values;
- Customer loyalty.

Alencastro (2002) also notes that social responsibility in business is a concept that applies to the entire production chain. Not only the final product should be evaluated for environmental or social factors, but the concept is of common interest and therefore should be disseminated throughout any production process, as the author points out.
As consumers, companies are also responsible for their suppliers and should enforce their codes of ethics to the products and services used throughout its production processes.

Social responsibility can be defined as:

"The commitment that an organization must have to society, expressed through acts and attitudes that affect positively, broadly, or any community in specific ways, acting proactively and consistently with respect to its specific role in society and accountability to her. " (Ashley 2005)

Social responsibility goes hand in hand with the concept of sustainable development. Responsible towards the environment and society, attitude not only ensures no shortage of resources, but also broadens the concept to a larger scale, as Ashley (2005) explains. The author argues that sustainable development refers not only to the environment but through the strengthening of durable partnerships, promotes the image of the company as a whole and ultimately leads to growth oriented. Therefore, a sustainable approach is preventive in nature and allows for the prevention of future risks, such as environmental impacts, or even lawsuits.

SUSTAINABILITY

A company that intends to sustain forever its business should adopt a strategy that contemplates the "triple bottom line" (triple counts of results), that is to say to generate value in the economic, environmental and social dimensions, a strategy to operate profitably without damaging natural resources, ecosystems and taking into account directly or indirectly related social causes with the company's activity. Sustainable development is increasingly present in the companies that position themselves as leaders in the market agenda.

The notion of sustainability has developed from the expression "sustainable development", whose concept is: "One that meets the needs of the present without compromising the ability of future generations to meet their own needs" Sustainable Actions to be, in fact, correct and applicable are required to be:

- Environmentally friendly;
- Economically viable;
- Socially just;
- Culturally accepted.

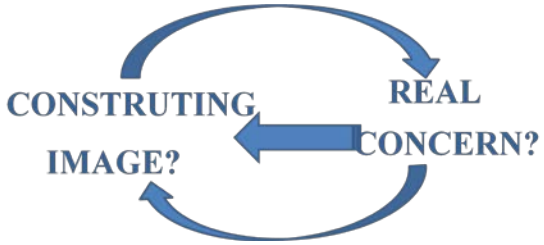
This concept of sustainability emerged in favor of the existing search to solve problems brought by uncontrolled exploitation of natural resources of the planet.

Combine CSR and Sustainability in Organizational Management, will it be possible?

It is possible to combine CSR and sustainability policies in Organizational Management, just depends on the willingness of our managers actually seek tailor their actions with simple management areas such as Human Resources, the community around you, care for the management of waste the preservation of the environment.

If we consider that in most developed countries the policies of preservation and conservation of the environment, prevention of noise and environmental pollution, are heavily regulated, just barely managing to responsibly adapt the use of these resources to the business conducted. Surely that investment will be different compared to the relocation of its activity to the so-called 3rd world countries where there are no policies for CSR or sustainable behaviors.

IN CONCLUSION, THE PERFORMANCE OF SOCIALLY RESPONSIBLE BUSINESS CAN CONTRIBUTE TO **“CONSTRUCT” THE CORPORATE IMAGE**



If we observe organizations that disclose their CSR policies and compare with the same organizations at 15 or 20 years ago we can not verify that they divulged their CSR actions. And to deepen the study came to the conclusion that there were no policies for CSR in the past these same organizations, why? Because the market was not as competitive, new media allowed the public awakening to their rights as citizens, as human resources organizations, as consumers, as customers of the organizations and finally as inhabitants of the same planet.
If the real concern of organizations consists of the policies of CSR and sustainability allied to management policies, it did not intend to build an image, then why promote these same actions?
It is very important that regulatory agencies and the general public are able to give preference to projects that follow the practice of applying concept of sustainability. Thus, it creates the necessary forces to gather favorable conditions for the creation, promotion and consolidation of a vision more aware and attentive to business issues related to the environment and impact of its projects.

If organizations disclose on their websites that use CSR policies and defend reason then why accept to work with countries where the work is insecure, in that organizations require their employees to work up to 18 hours a day, exploiting child labor, deplete and pollute their water resources, depleting forest resources.

Is necessary to create consciences in society, right from very early, on CSR and Sustainability policies, providing training from a young age, in our managers of the future. Implementing practices in schools about preservation of the environment, ethical behavior and being socially responsible. There will definitely be able to change the mindset of today's managers, however we all together work to change the minds of managers still social formation, growth as human beings and inhabitants of the same planet.
Certainly the birth of a new consciousness in the future managers will change the coveted by environmentalists and the public in general.

CSR can not be met only by a part of the company, for some areas of activity or employees. Be a "responsible" organization entails a commitment of the entire company, otherwise is just making small altruistic initiatives but not to assume their social responsibility.
There is no doubt needs to search for new parameters in social development. It is known that economic, social and cultural imbalance between social classes have compromised the improvements in quality of life. Thus it can be said that without Social Justice no conducive environment to raise a sustainable society.

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I am a student of Masters in Communication in Organizations in after labor time, and I am finishing the 1st academic year. I graduated in Marketing, Advertising and Public Relations and have a Postgraduate degree in Integrated Communications.
Ran for this Congress in the framework of a school chair named Research Methods and your acceptance contributed to a gain in my final evaluation. I´m working for 17 years in a multinational company in the field of Elevators, and I have functions of Credit Management.
It's the first time I attend a conference on sustainability and emphasize that my expectations are high, yesterday i received in simultaneous an invitation to attend another conference in September for which I hope to be better prepared thanks to the experience that I will now acquire.

Rethinking & Recasting the use of Bilateral Investment Treaties as tools for Sustainable Development: *The Kenyan Experience*

Ms. F. Simiyu
LLB (UoN), B.Ed. (KU), DipKsL (Nbi), LLM (EUR)
Assistant Lecturer, School of Law, Jomo Kenyatta University of Agriculture and Technology,
Contact Address:
P.O Box 18703-00100
NAIROBI, KENYA
Email: Faithsimiyu@gmail.com
Tel: +254 (0) 715 316 203

ABSTRACT

Sustainable development is a fundamental principle of International Law. It is closely related to and [should be] a core objective of any international treaty seeking to address developmental concerns. Curiously, however, a critical review of [legal] literature reveals seemingly little attention given to the actual assessment of 'how and to what extent' existing Bilateral Investment Treaties (BITs) have addressed sustainable developmental concerns. This is particularly in relation to BITs involving developing countries in Africa such as Kenya. Accordingly, taking Kenya as an illustrative case, this study made a critical assessment of the BITs concluded between Kenya, the Netherlands, Britain, and Germany; with a view to establishing how and to what extent the said BITs have addressed sustainable development. The study findings included that most (if not all) BITs remain silent on sustainable development. Further, the methods of addressing sustainable development are premised on placing host state obligations to protect investors and their investments. In doing so, the *implied* assumption is that protection will attract foreign investment necessary for financing sustainable development. Accordingly, states are urged to collectively rethink the usage of BITs as a tool for sustainable development by recasting the BIT structure to make sustainable development an *explicit* objective.

The study was divided into three sections. Section one examined the international law principles on sustainable development where the indicators of sustainable development were extracted as the conceptual framework for the study assessment. Section two provided a brief description of the nature and scope of BIT's with reference to the underlying assumptions on the usages of BITs as tool for sustainable development. Flowing from these assumptions and the indicators of sustainable development in section one, the mode and extent to which the Kenyan BIT's have incorporated the indicators of sustainable development were assessed in Section three and surmised by way of tabulations as given in page 3 below.

Keywords: Sustainable development, Foreign Investment, Bilateral Investment Treaties, foreign investor, host states

1.0. Introduction

Sustainable development has received worldwide recognition and acceptance as a fundamental framework of action to be taken internationally and nationally by governments, international organizations, and business enterprises in the pursuit of developmental concerns.[1] Gradually, sustainable development has now been embraced not only as a *common concern*[2] to both the developed and developing world; but also a global objective and commitment.[3] Equally, there is consensus that International Law (including International Investment Law through Bilateral Investment Treaties (BITs)) is pivotal in achieving sustainable development.[4] This acknowledgement has largely informed a number of initiatives already undertaken or being undertaken to make sustainable development an explicit objective of various treaties including BITs. Indeed, as Gehring and Newcombe have observed, more than fifty binding international treaties have sought to incorporate, in one form or another, sustainable development as an explicit objective.[5]

In retrospect, underpinning the awareness of, consensus on and global commitment to the promotion of sustainable development, there has been an evolution of the concept sustainable development; emergence and proliferation of BITs; and debates on the "how" aspect of achieving sustainable development in practical terms using BITs. [6] Specifically, it is argued that the drive to incorporate sustainable developmental concerns into BITs has largely based on two key assumptions: firstly, is that BITs are an important tool for attracting foreign investment which provides a viable source of capital for financing sustainable development. Secondly, that foreign investment should be promoted and protected through BITs; in order to induce the positive developmental benefits.[7] Curiously, however, there has been seemingly been little attention given to the actual analysis of how and the extent to which existing BITs

[1] Segger, C, M., Gehring, M, W., & Newcombe, A. (Eds.). (2011). *Sustainable Development in World Investment Law.* The Netherlands: Kluwer Law International pg 4-9.
[2] Gro H, Brundtland et al. 1987. Our Common Future: The Report of the World Commission on Environment and Development. Oxford: Oxford University Press
[3] Separate Opinion by H.E. Judge Weeramantry, Case Concerning Gabcikovo-Nagymaros Project (Hungary v. Slovakia), and [1997] I.C.J. Rep. 95.
[4] International Law Association. (2004). *First Report of the International Law Committee on International Law on Sustainable Developmen*t. London: International Law Association at pg. 3. See also Principle 27, Rio Declaration on Environment and Development, Agenda 21: Programme of Action for Sustainable Development, Report of the UNCED 1992, vol. U.N. GAOR, 46th Sess., and Agenda Item 21at Chapter 39.
[5] Ibid at n 1 page 5
[6] Segger et al op Cit n 1. See further International Institute for Sustainable Development. (2012). *Investment Treaties and why they matter for Sustainable Development: Questions and Answers*. Canada: International Institute for Sustainable Development.
[7] World Development Movement & Friends of the Earth. (2011). *Investment and the WTO: Bursting the Myths.* London: World Development Movement and Friends of the Earth.

have incorporated sustainable development. This is particularly so in relation to BITs involving developing countries such as Kenya.

Accordingly, taking Kenya as an illustrative case, this paper makes a critical assessment of the extent to which the BITS it has concluded with Germany, Britain and the Netherlands have addressed sustainable development. The BITs that are assessed comprise of (i) the Agreement for Economic Co-operation between the Government of the Kingdom of the Netherlands and the Government of the Republic of Kenya (hereafter referred to as the Netherlands-Kenya BIT); (ii) the Treaty between the Federal Republic of Germany and the Republic of Kenya (hereafter referred to as the German-Kenya BIT) and; (iii) the Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the Republic of Kenya (hereafter referred to as the UK-Kenya BIT). The structure of the said BITs is assessed and findings tabulated on the extent to which they have incorporated sustainable developmental concerns.

The paper begins by providing an overview of the meaning, pillars and principles of sustainable development. In doing so, the paper highlights how sustainable development has evolved from its initial conceptualization as merely a subtle element that describes man's attempt to live in harmony with nature, to its current conceptualization as consisting of three distinct but interrelated pillars, namely: economic development, environmental protection and social (human rights) development.[8] Further, the paper elucidates on how the pillars of sustainable development have over the years been underpinned by International Law principles on Sustainable development.[9] It follows, the International Law principles on sustainable development are used to extract indicators of incorporation of sustainable development. In turn, the said indicators are then used to examine the nature and scope of BITs and the extent of its usage as a tool for sustainable development in Kenya.

[9] Key among the conferences referred to above, which saw declarations and the enactment of various documents echoing the sustainable development principles and plans of implementation were held under the auspices of the United Nation (UN). These conferences include: i) the United Nations Conference on Human Environment held at Stockholm held in 1972; ii) the United Nation Conference on Environment and Development held at Rio de Janeiro in 1992**;** iii) the Johannesburg World Summit on Sustainable Development of 2002 and; iv)the 70th Conference of the International Law Association(ILA) held in New Delhi in 2002**.**

[9] Key among the conferences referred to above, which saw declarations and the enactment of various documents echoing the sustainable development principles and plans of implementation were held under the auspices of the United Nation (UN). These conferences include: i) the United Nations Conference on Human Environment held at Stockholm held in 1972; ii) the United Nation Conference on Environment and Development held at Rio de Janeiro in 1992**;** iii) the Johannesburg World Summit on Sustainable Development of 2002 and; iv)the 70th Conference of the International Law Association(ILA) held in New Delhi in 2002**.**

2.0. Meaning of Sustainable Development

The process of conceptualizing sustainable development dates back to the 18th and 19th century where man's religious beliefs and traditional norms guided his ability to interact with and exploit his environment. The common ground then was *'to live in harmony'* with nature and society.[10] This has arguably evolved into the current "living in harmony with nature" as a fundamental principle of sustainable development.

Today, there are various definitions of sustainable development. However, two definitions are significant. First is the most popular, accepted and commonly cited definition of sustainable development as provided in the Brundtland report, namely;

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.[11]

Second is definition of sustainable development as given by the International Law Association (ILA), which states that:

> Sustainable development [is] a comprehensive and **integrated approach** to economic, social and political processes[aimed] at the sustainable use of natural resources of the earth and the **protection of the environment** on which nature and human life as well as **social and economic development** depend, and which seeks to realize the **right of human beings** to an adequate living standard on the basis of their active, free, meaningful participation in development and in the fair distribution of benefits resulting therefrom, with due regard to the needs and interests of future generations… *emphasis added*[12]

Notably, the Brundtland report primes development, acknowledges inherent limitations of the environment and roots for inter and intra-generational equity.[13] More importantly, by laying emphasis on *'needs'*, it introduces the developmental concerns that must be addressed in the quest for sustainability. On the other hand, the definition by the International Law Association (ILA), adopted in this paper, conceptualizes sustainable development as being anchored on the integration and/or convergence between and among economic, social, and environmental imperatives that constitute the pillars of sustainable development. Indeed, the

[10] Mebratu, D. (1998). *Sustainability and Sustainable Development: Historical and Conceptual Review.* New York, NY: Elsevier Science Inc. at page 497

[11] Brundtland report op Cit n 2 at page 8, 46.

[12] International Law Association. (2002). *New Delhi Declaration on the Principles of International Law Related to Sustainable Development.* London: International Law Association

[13] Brundtland Report supra n 2 at Chapter 2. See also Drexhage, J, J., & Murphy, and D. (2010). Sustainable Development: From Brundtland to Rio 2012.Background Study Report prepared for consideration by the High Level Panel on Global Sustainability at its first meeting, 19 September 2010. New York: United Nations

ILA definition explicitly or implicitly espouses or introduces social (human rights), economic and environmental pillars of sustainable development. To this extent, this paper adopts the ILA definition on the basis that it is more comprehensive than that of the Brundtland report and more aligned to the key elements that constitute the focus of this paper.

3.0. Pillars of Sustainable Development

3.1. The Environmental Pillar of sustainable development

The environmental pillar of sustainable development is the most widely discussed and elaborated. It is acknowledged as the definitive part of 'sustainability' since what is to be 'sustained' can be classified either as nature, life support systems or the community.[14] Nature refers to the earth, biodiversity, and ecosystems which form a source of livelihood for mankind, while community means the peoples' culture, indigenous groups and places which must be protected.[15]

3.2. The Economic development pillar of sustainable development

Economic development as a pillar of sustainable development is considered the 'needs' part of sustainable development specifically, the meeting of 'economic needs'. Traditionally, economists defined 'economic development' based on quantitative indicators which was relating to economic growth or an increase in the average annual income per person (GNP per capita).[16] Thus, economic development was also defined as the:

> [The] process of transforming the conditions of underdevelopment (low productivity, stagnation, poverty) in countries variously designated as poor, underdeveloped, less developed, or developing as indicated by increased GNP per capita.[17]

In subsequent years, however, the definition of economic development has been extended to include qualitative indicators of economic development. These qualitative indicators include: improvements in material welfare of low income countries, poverty and disease eradication, increased literacy levels, shifts in production and consumption patterns, infrastructural development, technological transfer, improved standards of living and employment

[14] Kates, W, R.; Parris, M, Thomas & Leiserowitz, A. Anthony. (2005). *What is Sustainable Development? Goals, Indicators, Values, and Practice.* Washington: United States.
[15] U.S National Paper Council, Policy Division, Board on Sustainable Development. *Our Common Journey: A Transition towards Sustainability*. Washington DC: National Academy Press, 1999.
[16] World Bank Annual publication Word Development Report 2003
[17] ipsa

conditions.[18] Notably, poverty eradication is an important principle of sustainable development.

3.3. Social(human rights) development pillar of sustainable development

Modern development economists provide a human rights approach to development by arguing that development requires the *removal of major sources of 'unfreedom'***.** These are poverty, tyranny, poor economic opportunities, systematic social deprivation or lack of equity, neglect of public facilities, as well as repressive and intolerant states.[19]In this regard, development can be said to correlate to human freedoms and human rights. Thus, there can be no meaningful development without the guarantee of individual entitlements, capabilities, freedoms and/or rights. Arguably, the human rights approach to development introduces the social dimension of development. This is also the social (human rights) approach to sustainable development. As we shall see, human rights are considered important principles of sustainable development.

4.0. International Law Principles Of Sustainable Development

The International Law principles on sustainable development emerged from several conferences that adopted, fortified and enacted policy documents echoing sustainable development principles. Of particular importance to this paper is the 70th Conference of the International Law Association (ILA) held in New Delhi in 2002.The ILA conference saw the enactment of the 'New Delhi declaration on International Law principles relating to sustainable development' (ILA Declaration). The ILA Declaration contains seven (7) International Law principles on sustainable development namely:(i) the principle of integration and inter-relationship; (ii) the principle of common but differentiated responsibilities, (iii) the 'precautionary principle'; (iv) the principle of good governance;(v) the principle of public participation; (v) the principle of equity and poverty eradication; (vi) the principle duty of states to ensure sustainable use of natural resources. Each principle entails socio-economic and environmental pillars of sustainable development which are used as indicators of incorporation of sustainable development as explained below.

[18]Hardwick, Bahadur.; & Langmead. (1999). *An Introduction to Modern Economics* (5th Ed.). United Kingdom: Longman Publishers pg 7

[19] Sen, A, K. (1999). *Development as Freedom*. United Kingdom: Oxford University Press

5.0. Indicators of Incorporation of Sustainable Development Principles

An indicator, as used in this paper, refers to a specific, identifiable attribute or aspect that one has to look for in a given BIT that if present (whether explicitly or implicitly) would show or *indicate* that a particular principle on sustainable development has been incorporated. As discussed, the ILA Declaration introduced seven (7) principles that underpin sustainable development. Below we examine four (4) of the principles to be used for the study assessment of the extent of incorporation of sustainable development in the Kenyan BITs.

5.1. The Principle Of Precautionary Approach To Human Health, Natural Resources And Eco-Systems

The precautionary principle commits all states, international organizations, the civil society and the business communities, to avoid human activities that may cause significant harm to human health, natural resources and eco-systems.[20] The precautionary principle requires action to prevent environmental damage be taken even 'before scientific proof of harm is provided'.[21] To achieve this, two main activities are envisaged namely; i*) accountability for environmental harm and ii) Environmental impact assessment (EIA)* before carrying out a project at a natural site. Therefore, by incorporating this principle into BITs, one will be taking precautions to mitigating potential environment harm that may affect a people's right to a clean and healthy environment. Given the focus on the environment, this principle falls under the environmental protection pillar of sustainable development, for our assessment purposes.

5.2. The Duty Of States To Ensure Sustainable Use Of Natural Resources

The 'sovereign right' of states over the natural resources in their own territories has informed state duty to uphold this principle pursuant to their own environmental and developmental policies. States have the responsibility to ensure that the activities within their jurisdiction do not cause environmental damage to other states. Further, due regard is given to the conservation and sustainable use of natural resources.[22] Certainly, the environment is of particular concern in this principle and therefore this principle falls under the environmental protection pillar of sustainable development.

5.3. The Principle Of Equity and Poverty Eradication

[20] See Article 4.1 of ILA Declaration
[21] Howley, J. (2009). The Gabcikovo-Nagymaros Case: The Influence of the International Cour of Justice on the Law of Sustainable Development. *Queensland Law Student Review Volume 2 number 1.*
[22] Articles 1.1 and 1.2 of ILA Declaration

This principle essentially commits states to ensure both inter-generational and intra-generational equity and the eradication of poverty. On one hand, 'intra and inter-generational equity' is indicated by fair access to natural resources by peoples of the current and future generations. [23] On the other hand, 'poverty eradication' is indicated by a commitment to improving the standards of living for all peoples.[24] This requires measures being taken to ensure that the nation and its people are economically empowered in terms of raising their standards of living. Collectively, it can be argued equity and poverty eradication seeks to meet the economic 'needs' of mankind for prosperity and posterity. Therefore, both principles fall under the economic pillar of sustainable development.

5.4. The Principle of Public Participation

This principle calls upon public participation or involvement in all levels of decision-making at the national or international level. The public in this context includes women, youth, and civil societies. Amongst the specific requirements of this principle is the protection of the human rights to hold and express opinion as well as the right to access judicial or administrative procedures. [25] Arguably, given the focus on the 'people' as social beings, this principle therefore falls within the social (human rights) pillar of sustainable development.

Table 1 below provides a summary of the preceding principles and how they are to be used as indicators of incorporation of the pillars of sustainable development.

[23] Article 2.1 and 2.2 of the ILA declaration
[24] Principle 5 of the Rio Declaration
[25] Article 5.3 ILA Declaration

Table 1: Pillars, Principles and Indicators of Sustainable development

Pillar	Principle	Indicators
Environment	**Precautionary Principle**	• Commits parties to avoid human activities that may cause significant harm to human health, natural resources or the eco-system • Incorporates accountability of environmental harm • Prioritizes environmental impact assessment
	State responsibility for ensuring sustainable use of natural resources	• Recognizes and upholds(affirms) rights and responsibilities pursuant to a host states own environmental and developmental policies • Promotion of waste minimization policies • Demonstrable or implied sensitivity to the environment within and beyond borders
Economic Development	**Poverty Eradication**	• Encourages co-operation for the eradication of poverty in a manner that improves the living standards of all people for prosperity and posterity
	Equity	• Guarantees, promotes or provides inter- and intra- generational equity in terms of fair access to natural resources
Social Development	**Public Participation**	• Guarantees the right to access judicial organs and business information • Uphold the rights to express opinions and access information • Considers the participation of the public in development

Source: Author

6.0. Nature and Scope of Bilateral Investment Treaties

Bilateral Investment Treaties (BITs) are a subset or category of International Investment Agreements (IIAs) concluded at the bilateral level. They consist of the primary mechanism by which foreign investment is governed. Most BITs are concluded between developed and developing countries and represent a 'bargain' involving the developing country(as the host) promising to protect foreign investment in exchange of increased foreign capital inflow from the developed country.

The first BIT was concluded between Germany and Pakistan in 1959. In subsequent years, the period between the 1960's to 1970's witnessed the conclusion of several BITs between developed and developing countries. Of peculiarity is the fact that the BITs exclusively addressed the protection of investment.[26] The assumption was that through according higher levels of protections to foreign investment, host states would be able to attract and reap the economic benefits of foreign investment. By the early-1980's, a certain trend emerged:- when concluding BITs, developing countries sought to create a stable, transparent, and predictable climate for the conduit of investment activities through according higher levels of protection to foreign investors. Thus, the substantive provisions of BITs were largely tailored towards protecting investors through minimum standards of treatment clauses that included: *fair and*

[26] Newcombe, A & Luis, P. (2009). *Law and Practice of Investment Treaties: Standards of Treatment.* The Netherlands: Kluwer Law International.

equitable treatment of investment in accordance to customary international law, the guarantee of full protection and security of investment, Most-favoured Nation treatment and the guarantee of compensation in case of expropriation. These minimum standards of treatment established the traditional role of BITS as legally binding instruments for protecting foreign investment.

From the 1980's, changing economic and political realities challenged the traditional role of BITs; as legally binding instruments for protecting foreign investment. The changes precipitated the need to rethink the traditional scope of BITs as protectors of investment, to address development generally and sustainable development in particular. Amongst the important political and economic changes of this period was the process of decolonization and the sovereign debt crisis of the mid- 1980's. On one hand, the process of decolonization saw the removal of economic dominance in developing countries hence developing counties wanted to assert their rights as 'sovereign' states in the process of regulating foreign investment to induce development. On a different note, the sovereign debt crisis of the mid-1980's triggered the unwillingness of commercial banks to provide lending facilities in the form of official capital flow, to developing countries. In turn, this necessitated the search for alternative sources of capital in the form of foreign investment. [27] As a result, developing countries pursued programs aimed at liberalizing and protecting investment as a means of attracting and reaping the associated developmental benefits of investment through BITs.[28]

By the end of the 1990's foreign investment was widely regarded as *'part of the solution'* to advancing development.[29]Two key assumptions guided the usage of IIAs including BITs as tools for addressing developmental generally and sustainable development in particular. Firstly, foreign investment, especially Foreign Direct Investment (FDI), provides a viable source of capital for financing sustainable development. Secondly, foreign investment should be promoted (or encouraged), and protected through appropriate national and international regulatory frameworks under BITs in order to induce the positive developmental benefits

[27] Pritchard, R. (1996).*Economic Development, Foreign Investment and the Law: Issues of Private Sector Involvement, Foreign Investment, and Rule of Law in a new Era*. The Hague London and Boston: Kluwer Law International and International bar Association.
[28] CFIUS, Annual Report to Congress, Report Period CY2010 (Washington, DC: CFIUS, 2011).
[29] Savant, K. (2012). *The times they are a-changing'-again-in the relationships between governments and multinational enterprises: From control, to liberalization to rebalancing*. Canada: Vale Columbia Center on Sustainable International Investment.

associated with investment.[30] These assumptions have in turn informed the methods by which BITs incorporate sustainable development.

7.0. Bilateral Investment Treaties as Tools for Sustainable Development in Kenya

In accordance with the pillars and indicators of incorporation of sustainable development identified in the preceding sections, we conducted a critical assessment of how the Kenyan BITs have incorporated sustainable development. The assessments unearthed three methods by the Kenyan BITs impliedly or explicitly incorporate sustainable development. These are by way of preambular declarations, specific declaratory clauses; and general exception clauses.[31] Table 2 below provides a summary of the findings and is followed by a critical assessment of the audit results as on the extent of incorporation of sustainable development in the Kenyan BITs.

Table 2: Analysis of BITs and Extent of Integration of Principles of Sustainable Development

BIT	**BIT Structure**	**Principle of Sustainable Development**					
		Environmental protection			**Economic Dev.**		**Social Dev.**
			Precautionary Approach to human health, natural resources and eco-systems	State responsibility for ensuring sustainable use of natural resources	Poverty Eradication	Equity	Public Participation
Netherlands-Kenya BIT	Preamble		X	X	✓		X
	Specific declarations		X	X	X	X	X
	General exceptions		X	X	X	X	✓
German-Kenya BIT	Preamble		X	X	✓		X
	Specific declarations		X	X	X	X	X
	General exceptions		X	X	X	X	✓
UK-Kenya BIT	Preamble		X	X	✓		X
	Specific declarations		X	X	X	X	X
	General exceptions		X	X	X	X	✓

Source: Author **KEY**

✓ Implies that the stated principle of Sustainable Development has been incorporated

X Implies the stated principle of Sustainable Development has not been incorporated

7.1. Assessment of the Extent of Incorporation of Sustainable Development by Kenyan BITs

[30] Ibid n 7.

[31] UNCTAD. (2004). *Key Terms and Concepts in IIAs: A Glossary. Series on Issues in International Investment Agreements*. United Nations: New York and Geneva

7.1.1. BITs and the Environmental Protection Pillar

It is evident from table 2 that as far as the environmental protection pillar is concerned, none of the BITs explicitly incorporate the realization of environmental protection either as a preambular declaration, specific declaration or as a general exception. As discussed, environmental protection as a pillar of sustainable development is underpinned by two key principles, namely: *precautionary approach and state responsibility for ensuring sustainable use of natural resources*. None of these principles are incorporated into the three BITs.

In retrospect, one provision of the Netherlands-Kenya BIT could be said to imply efforts towards incorporating the environmental pillar of sustainable development. Article 3 of the Netherlands –Kenya BIT explicitly provides that:

> The Contracting Parties shall facilitate the intensification of commercial relations between their respective countries. They shall, within the framework of and subject to their national legislation, further the co-operation between the companies, associations, foundations and other organisations of any kind or subsidiary bodies thereof, which are connected with their economic life, and all their nationals engaged in economic activities, in order to **develop their national resources**…*emphasis added*

The immediate article infers some level of sensitivity to the environment by the contracting states where each needs to develop national resources. Impliedly, national resources may include the environment which can be developed or exploited to cater for environmental needs. In retrospect, however, because Article 3 refers to the notion "national" resources instead of '*natural'* resources or '*sustainable utilization of the natural resources*'; it can be construed that its provisions do not aptly capture the indicators of incorporating the environmental protection pillar.

7.1.2. BITs and the Economic Development pillar

The extent to which the three BITs have addressed the economic development pillar of sustainable development was analysed with specific reference to two principles namely: *poverty eradication*; and *equity*. Collectively, the two principles encourage co-operation for the eradication of poverty so as to raise living standards and for equity in terms of fair access to natural resources.

From table 2, it is evident that the preambles of the three BITs address, to a certain extent, the economic development pillar of sustainable development. In particular, the preambles of the three BITs seek to protect and promote investment on the assumption that this will increase

the economic prosperity of the Kenyan state leading to economic development. To do this, the BITs objectify three items namely; (*i) the creation of favourable conditions for investment; (ii) the encouragement and reciprocal protection of investment in a manner that will stimulate individual business initiatives and increase prosperity; and (iii) the intensification of economic relations.* For instance, the preamble of the UK-Kenya BIT provides:

> The Government of the United Kingdom and of Great Britain and Northern Ireland and the Government of the Republic of Kenya;
> Desiring to **create favourable conditions for greater investment** by nationals and companies of one state in the territory of the other state;
> Recognising that the **encouragement and reciprocal protection under international agreement of such investment will be conducive to** the simulation of individual business initiative and will **increase prosperity of both States**…*emphasis added*

Similarly, the preamble of the German-Kenyan BIT seeks to:

> …**create favourable conditions for investment** by nationals and companies in the territory of the other state recognizing that the encouragement and contractual **protection of such investments are apt to stimulate private business initiative and increase [economic] prosperity** of both nations…*emphasis*

Related, the preamble of the Netherlands-Kenyan BITs provides:

> The Government of the Kingdom of the Netherlands and the Government of the Republic of Kenya, Desiring to strengthen their traditional ties of friendship, to extend and intensify their economic relations and to **encourage investments on the basis of equality to their mutual benefit**…*emphasis added*

The foregoing objectives are in line with the assumption that foreign investment should be protected as a way of attracting and reaping sustainable developmental benefits. They also reinforce the fact that a country's 'prosperity' is pegged on an increase in investment inflow. Notably, even though the BITs refer to '*increasing prosperity*', they neither make reference to the sustainable economic development nor do they create any obligations on the contracting nations to promote inter-generational and intra-generational equity and poverty eradication. Thus, it is deducible that the quest to incorporate the economic pillar of sustainable development under the BITs is nugatory.

On the contrary, the Netherlands-Kenya BIT presents the most progressive efforts made to address the economic pillar of sustainable development, albeit with limited success. Specifically, Article 2 of the Netherlands-Kenya BIT makes direct reference to the economic pillar of sustainable development by seeking to:

> … [foster] co-operation between the state contracting parties, companies, associations and other organizations…connected with their **economic life** and all nationals engaged in **economic activities** in order to develop their **national resources**…*emphasis added*

The said article indicates recognition of the place of other relevant actors when fostering co-operation in pursuit of economic activities, which could lead to the eradication of poverty because "resources" can be exploited to meet economic needs.

7.1.3. BITs and the Social Development pillar

The social development pillar is indicated by a guarantee of the right to access judicial organs and the participation of the public in development. As far as the Social pillar of sustainable development is concerned, none of the preambular and specific declarations of the three Bits explicitly incorporate a commitment to the social pillar of sustainable development. However, the general exception clauses of the three BITs somehow attempt to advance the social pillar of sustainable development in the case of 'expropriation' for a public benefit. [32] For instance, Article 9 of the Netherlands-Kenya BIT allows *any* measure of expropriation so long as the same is accompanied by the payment of adequate compensation. Specifically, the Article 9 provides:

> Any measures of nationalisation or expropriation, taken by either of the Contracting Parties affecting the investments, goods, rights or interests of their respective nationals in the territory of each other, shall be followed by payment of adequate compensation, transferable to the extent necessary to make it effective, within a reasonable time and in accordance with generally recognised rules of international law.

Similarly, Article 5 of the UK-Kenya BIT allows expropriation for public purposes relating to the '*internal needs'* of a state but requires such measures to be followed by the payment of compensation.

> Investments of nationals or companies or either Contracting Party shall not be nationalised, expropriated …in the territory of the other Contracting Party except for a public purpose related to the **internal needs** of that Party on a non-discriminatory basis and against prompt, adequate and effective **compensation**…*emphasis added*

Additionally, Article 4(2) of the German-Kenya BIT also allows expropriation for '*public benefit'* upon payment of compensation as follows:

> Investments of nationals or companies or either Contracting Party shall not be nationalised, expropriated …in the territory of the other Contracting Party except for a **public benefit** and against compensation…*emphasis added*

[32] By expropriation, we mean the *taking by the government of tangible or intangible property owned by private persons by means of administrative or legislative action*. See further Tecmed v Mexico, ICSID ARB(AF)/00/2,Award,29 May 2003 Para 113

Collectively, the foregoing provisions suggest that the 'public' as an inherent principle within the social pillar of sustainable development is addressed under the said BITs. As the articles provide, the investor protections inherent in the three BITs may pave way for measures amounting to expropriation in the interest of the public.

The 'public interest', in most cases, refers to a pecuniary or some interest borne by a 'class of community' but virtue of which their legal rights are affected. The interest can be economic, social or environmental so long as it is borne by a community. [33]Accordingly, one may deduce that the three BITs seek to secure the 'public' participation as an underlying principle of the social development pillar. However, drawing such a deduction would negate the truth. This is so because public participation under the social pillar of sustainable development envisages not only involvement of all interested parties in decision-making but also access to judicial organs.[34]

From the foregoing assessment and as evident form Table 2, it is deducible that to a large extent the three Kenyan BITs has failed to explicitly incorporate sustainable development. Notably, the substantive provisions of each of the BITs largely seek to protect the interests and rights of the investors through the minimum standards of treatment clauses. The emphasis on protection seems to merely propagate the assumption that it will stimulate an inflow of foreign investment leading to sustainable development. It is no surprise then that the minimum standards of protection formed the bulk of the substantive provisions whilst there were no explicit provisions on sustainable development. Table 3 below shows the distribution ratio of the substantive provisions on minimum standards of treatment clauses that protect foreign investment in comparison to the provisions on sustainable development.

[33] As per LJ Campbell in *Republic vs. Bedfordshire* (24.L.J.Q.B.84).
[34] See Article 14 of the Netherlands-Kenya BIT, Article 1 of the German-Kenya BIT and Article 3 of the UK – Kenya BIT.

Table 3: Distribution ratio of substantive provisions on minimum standards of treatment clauses that protect foreign investment viz the provisions on sustainable development

BIT	Total No of Clauses	No of clauses explicitly incorporating sustainable development	No of clauses on minimum standards of treatment clauses protecting foreign investment	Content of remaining clauses
German-Kenya BIT	13	0	6	Remaining clauses dealing with procedural matters such as definitions, mode of settling disputes, territorial application, entry into force, etc.
UK-Kenya BIT	14	0	5	Same as above
Netherlands-Kenya BIT	18	0	6	Same as above

Source: Author

8.0. Conclusion

The assessment on how and to what extent the current investment law regime has addressed sustainable development using the Kenyan BITs as illustrative examples, has showed that to a large extent, sustainable development remains a mirage. The lack of incorporation of the pillars and the principles of sustainable development warrants this assertion. The Kenyan BITs have largely favoured the rights and interests of investors in having their investment protected through minimum standards of treatment clauses that enable BITs fulfil their traditional role of protecting foreign investment. Although it can be said that the minimum standards are in line with the assumption that by protecting foreign investment, one can reap sustainable development benefits, such an assumption is not enough. Ultimately, States must rethink how the BITs can incorporate sustainable developmental concerns whilst at the same time fulfilling their traditional role of promoting and protecting investment. The states must take deliberate steps recast BITs to ensure that the process of negotiation of BITs, the structure that emanates from the negotiation and the implementation of the BITs; explicitly seek to incorporate sustainable development.

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Risk Assessment Using Monte Carlo Simulation Approach For Very Small Biomass Powerplant Investment Case Study:Phitsanulok Province in Thailand

Apakorn Pantuwacharapol

Energy Technology and Management Program,Chulalongkorn University
Apakorn33@gmail.com

ABSTRACT

The decision investment alternatives for Biomass power plant with capacity less than 1 MW was considered in five alternatives.These investment alternatives are: investment in power plant capacity 350 KW 1 plant and consider risk assessment for additianal investment until 1MW orinvestment in power plant capacity 500 KW 1 plant and consider risk assessment for additianal investmentuntil 1MW or investment in power plant capacity 350 KW 2 plants and synchronous 300 KW 1 plant together or investment in power plant capacity 500 KW 2 plants synchronous together or last alternative investment in power plant capacity 1000 KW 1 plants.Due to the uncertainty of the availability bimass fuel (Corncob and Giant King Grass G-120) one kind fuel only or switching fuel by seasonal.Risk assessment from many factors that related the investment such as initial investment capital and different investment alternatives:variance of float time rate (Ft),Price of fuel and variance of Consumer Price Index.The results from Sensitivity Analysis is the most sensitive on the initial investment capital follow by price and quantity of biomass fuel respectively .The risk assessment of the project return was performed using Monte Carlo simulation approach on the discounted cash flow model (DCF).The results provide some insights for the planning of financial returns and biomass fuels usage.

KEYWORDS

Risk Assessment,Gasification Power Plant,Monte Carlo Simulation

1.Introduction

Currently, private power plant investors are more interesting to invest in the very small power plant.Due to centralized electricity has reduced fossil fuel quantity. Including the government support for the production of electricity from renewable energy. Power plant investors to turn to private investment in biomass power plants smaller than 1 MW require a long-term investment planning. To avoid the risks that can occur. Decision making under uncertainty. The decision to invest in the project, considering the basic financial numbers is important to evaluate the financial strategy. Most of the decision whether to invest or not to invest. Or invest , how much capacity is appropriate. Executive to decide the choice of investments to benefit the greater good. In the valuation of options for the construction of comprehensive factors in the investment business, most of the biomass power plant to be reckoned with. Element in many aspects , whether it is a large capacity . Fuel Prices and changing rate of the Ft [1] [2] as well as support from the government [3], which can affect the price of electricity.

2.Objection

Assessment the risk level of the investment of biomass powerplant. To reduce risk and maximum return.

3.Characteristic of Data

This research as guideline in the decision to invest in different capacity powerplant to suitably different production costs . And satisfy the needs of investors. By using the financial indicators and testing simulation Monte Carlo (Monte Carlo Simulation) biomass power plant in which the investment is very small. There are many factors that affect investment decisions. Choose to use this tool to help in the two types consider which is defined by the following options .

Option 1 invested in power plant 350 KW two plants and 300 KW one Plant simultaneously.

Option 2 invested in power plant 350 KW power plant just one plant. Then decided to invest.

Option 3 invested in power plant 500 KW two plants simultaneously.

Option 4 invested in power plant 500 KW power plant just one plant. Then decided to invest.

Option 5 invested in power plant 1,000 KW

Due to multifeestock gasification system applications that choose to use the biomass power plant , which can be used for various types of fuel .

The main fuel used in the research was conducted as corncobs and Napier grass for use as a secondary fuel. The corncobs were seasonal fuel switching to napier grass during the summer corncob has low volume about 4 months .

Analysis using Monte Carlo simulation to give the variance of chaning in various factors. That affect investment. To take into account the risk of the fund .

4.Study Process and Collected Data

To collect data used in decision-making capacity in the investment selection using the following data.

4.1.1 study potential electricity production from corncobs . Include suitable quality of napier grass by local for the electrical power , including the amount of the price and compare features on the local weather durability . Harvesting and care the other fuel plants ,the heating value such as Acacia giant stalks of sugar cane , cassava, this research used the purchase of napier grass reference followed by corncob price. Because this local don't planting napier grass for commercial .

4.1.2 Analysis return of investment projects from five alternatives.

4.1.2.1 Estimated using discounted cash flow model (Discounted Cash Flow Model)by financial indicators (Net Present Value: NPV) which in this research is to use the weighted average cost of capital WACC (Weighted. Average Cost Of Capital) of a company case study as a reference value in the calculation.

Principle decision (NPV)

If NPV is positive, because your investment is profitable if the NPV is negative or zero should not invest because of loss or par.

It also uses the internal rate of return IRR (Interal Rate of Return) and compare the two metrics of all 5 alternatives.

4.1.2.2 Sensitivity analysis of factors that affect the financial return of the project .Project investments under consideration for future investment opportunities may be occur uncertainly.

4.1.2.3 Testing Monte Carlo Simulation to help in the calculation of the variance.

This model parameters , which can calculate the result of many variables. Variables are changed simultaneously by sampling the variable that changes according to the distribution of the variable to get the value that is closest to the most real chance .

Gasification Multi-Feed stock

The production of generator gas (producer gas) called gasification,is partial combustion of solid fuel(biomass) and takes place at temperatures of about 1000 °C.The reactor is called a gasifier.

The combustion products from complete combustion of biomass generally contain nitrogen,water vapor,carbon dioxide and surplus of oxygen.However in gasification where there is a surplus of solid fuel(incomplete combustion)the products of combustion are combustion gases like Carbon monoxide(CO),Hydrogen (H_2) and traces of Methane and nonuseful products like tar and dust.The production of these gases is by reaction of water vapor and carbon dioxide through a glowing layer of charcoal.Thus the key to gasifier design is to create conditions such that

a) Biomass is reduced to charcoal and.,
b) Charcoal is converted at suitable temperature to produce CO and H_2

5.Type of Gasification

Since there is an interaction of air or oxygen and biomass in the gasifier,they are classified according to the way air or oxygen is introduced in it. There are three types of gasifiers; Downdraft,Updraft and Crossdraft. And as the classification implies updraft gasifier has air passing through the biomass from bottom and the combustion gases come out from the top of the gasifier.Similarly in the downdraft gasifier the air is passed from the tuyers in the downdraft direction.

Sr.No.	Gasifier Type	Advantage	Disadvantage
1.	Updraft	-Small pressure drop -good thermal efficiency -little tendency towards slag formation	-Great sensitivity to tar and moisture content of fuel -relatively long time required for start up of IC engine -poor reactive capability with heavy gas load
2.	Downdraft	-Flexible adaption of gas production to load -low sensitivity to charcoal dust and tar content of fuel	-Design tends to be tall -not feasible for very small particle size of fuel
3.	Crossdraft	-Short design height -very fast response time to load -flexible gas production	-Very high sensitivity to slag formation -high pressure drop

Table 1. Advantages and Disadvantages of various Gasifiers (http://www.nariphaltan.org/gasbook.pdf)

Downdraft Gasification

Biomass flow from top to bottom in the same direction because biomass ,gas ,air will to move in the same direction near combustion zone. This position is designed like bottleneck for severe burn in this hot zone . Cause the volatile solids and tar formed by the process of pyrolysis stack into gas when they are moving through areas with high temperatures.

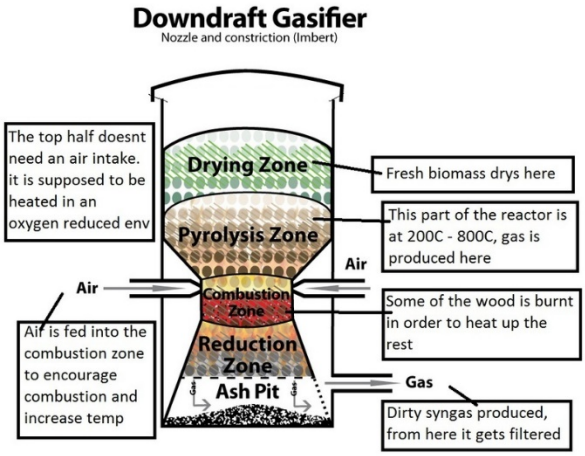


Figure 1. Downdraft Gasification (http://www.tripme.co.nz)

6.Risk

The situation is expected to occur in the future under uncertainty but It can be predicted by using the probability of occurrence of an event to help in the analysis.

Decision making under risk Analysis

The situation under risk can be a form of probability distributions.Thus the opportunity of event can determine from probability since 0 to 1 ; probability = 0 means this event doesn't occur but probability =1 mean this event has certainly occurred.We can determine risk from Monte Carlo Simulation.This simulation shows deviation of Net Present Value (NPV) due to the changing of various factors.Some event has high deviation which has high risk and event has low deviation which has low risk.However the comparison of risk should be study occasion of NPV less than 0 because some event has small deviation but partial of deviation graph has probability less than 0.

The probability may be discrete deviation form or continuous deviation form

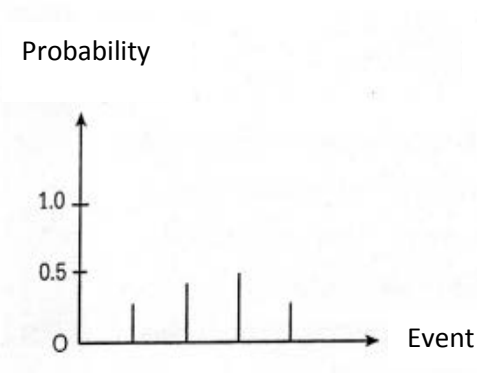


Figure 2. Discrete Deviation Graph

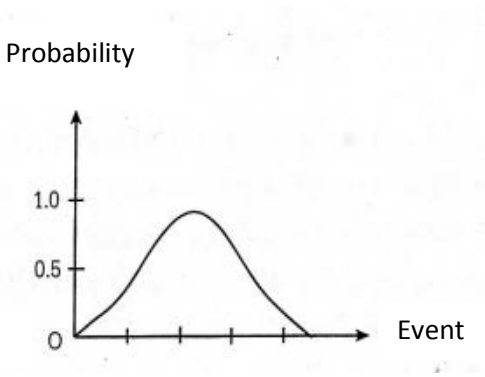


Figure 3. Continuous Deviation Graph

Characteristic of deviation of probability have many format that have the most important for the decision analysis the project risk.(See Figure 4. The risk of project)

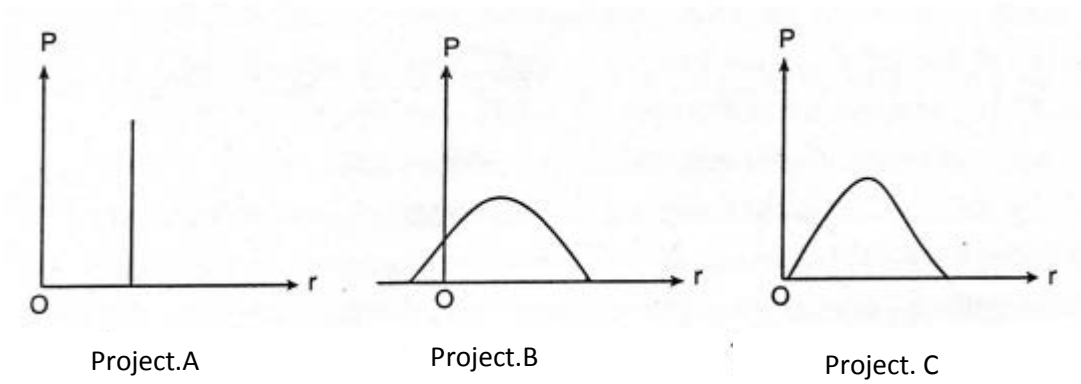


Figure 4. The risk of project

From **Figure** 4.Project A and C no loss mean while project B chances to loss because the partial area of the deviation of probability line in less than 0 area so project B is high risk when comparison among A and C project because the comparison of project B has occasion less than 0 is high but project A no risk because don't it doesn't has the deviation of event.

Financial Options[8]	Real Options[8]
Short maturity,usually in months.	Longer maturity,usually in years.
Underlying variable driving its value is equity price of a financial asset.	Underlying variables are free cash flows,which in turn are driven by competition ,demand ,management.
Cannot control option value by manipulating stock prices.	Can Increase strategic option value by management decisions and flexibility.
Values are usually small.	Major million and billion dollar decisions.
Competitive or market effects are irrelevant to its value and pricing.	Competiton and market drive the value of a strategic option.
Have been around and traded for more than three decades.	A recent development in corporate finance within the last decade.
Usually solved using closed-form partial differential equations and simulation/variance reduction techniques for exotic options.	Usually solved using closed-form equations and binomial lattices with simulation of the underlying variables,not on the option analysis.
Marketable and traded security with comparables and pricing info.	Not traded and proprietary in nature,with no market comparables.
Management assumptions and actions have no bearing on valuation.	Management assumptions and actions drive the value of a real option.

Table 2. Comparison between Financial and Real Options

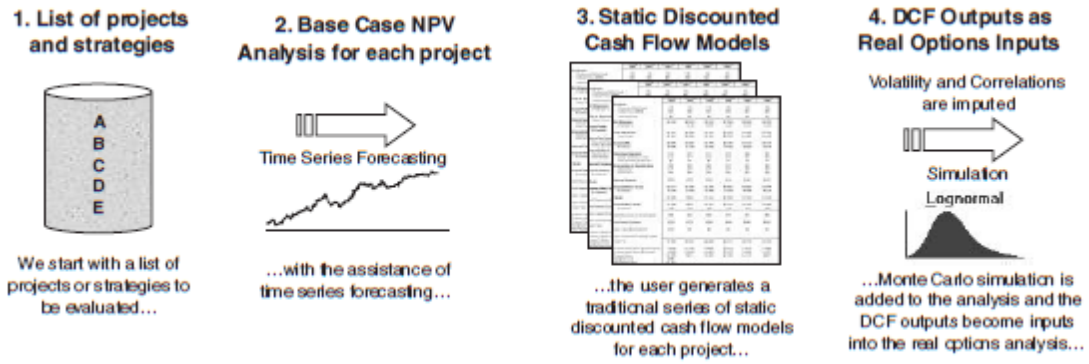
7.The Evaluation Process

An analyst should discuss with management pertaining to real options analysis is the steps taken to obtain the resules-in other words,what the process flow looks like,how it makes logical sense,and where the traditional analysis ends and the new analytics take over.A thorough under-standing of the process flow will make management more comfortable in accepting the results of the analysis.A career-limiting or a high-potantial career-ending move is to show management a series of complicated stochastic differential to calculus equations,crunch on a number,and then ask the CEO to bet the company's future on it.How can management buy in on an analysis if the analyst can't even explain the process flow properly? **Figure 5.**shows a visual repretation of the process flow for a robust real optiona analysis process.

In the first step,the analyst starts off with a list of qualified projects,that is,projects that have been through qualitative screening by management.Having met preset criteria,whether they be strategic visions or goals of the company,these are the projects that need to be analyzed.They may of course be different courses of actions,initiatives,or strategies.For each of these strategics or projects,the base-case NPV analysis is performed,as indicated in step two.This could be done in terms of the market,income,or cost approach,using something akin to a discounted cash flow model,as seen in the third step.In certain circumstances,the analyst may elect to perform some intermediate calculation like time-series forcasting and simulation to predict future revenue and cost streams.Depending on the availability of historical data,some fancy econometric,forecasting,regression,time-series,cross-sectional,or stochastic model may be constructed for this purpose.These three steps encapsulate the traditional approach.Using the revenues and cost structures coupled with conventional accounting procedures,the analyst would calculate the net present value of the projects or strategies.Occasionally,other financial metrics may be used,such as an internal rate of return(IRR) or some form of return on investment(ROI) measure.In most cases,a decision will be made based on these deterministic results.

In more advanced financial analysis,specifically,a recommended step for the real options approach is the application of Monte Carlo simulation .Based on some sensitivity analysis,the analyst decides which input variables to the discounted cash flow model previously constructed are most vulnerable to risks and sudden exogenous and systemic shocks.Using historical data,the analyst can take the time-series or cross-sectional data and fit them to a multitude of different distributions. The analyst may also opt to use management assumptions,hunches,experience,or economic behaviors of variables to make the distributional determination. The discounted cash flow model is then simulated.The result is a distribution of the variable of interest,for example,the net present value.Instead of obtaining single-point estimates,the analyst now has a probability distribution of outcomes,indicating with what probabilities certain outcomes will most likely occur.Based on this Monte Carlo simulation,certain intrinsic variables key to the real options analysis are calculated and imported into the real option analysis.These key variables that flow out of the simulation procedures include the volatility of the underlying variable,typically the lognormal returns on the future free cash flows;the

implied cross-correlation pairs between the underlying projects;and the expected present



value of cash flows.

Figure 5. Real Option Process Summary

8.Biomass Energy

It is a kind of fuel deried from organic substances,such as agricultural residues like woodchips,bagasse and paddy husks,animal manure from livestock farms,wastes from agricultural product processing,and wastewater from factories.Biomass can be an important energy resource,and the resources of biomass are distributed across the country. For instance,paddy husks are burned to produce steam for turbine operation in rice mills;bagasses and palm residues are used to produce steam and electricity for on-site manufacturing processes;and rubber wood chips are burned to produce hot air for rubber wood seasoning.Moreover,the remaining biomass can be used for power generation.

9.Monte Carlo Simulation

This Simulation is a probability distribution by a discrete random rely on variable. The situation is under random conditions . Behavior of the random variable. Each event was not related variables with uncertainty that opportunity occur in every investment. In

fact, the variables can be changed in different directions simultaneously , such as fuel prices . Fuel consumption Consumer Price Index [5], including investments and find the distribution of data. For use in modeling. The resulting model is used to indicate the variability of the variable changes . The test sample variable data characteristics change according to the distribution of that variable to get close to the information that is likely occured in the future as much as possible .

10.Monte Carlo simulation versus "what if" scenarios

There are ways of using probabilities that are definitely not Monte Carlo simulations for example, deterministic modeling using single-point estimates. Each uncertain variable within a model is assigned a “best guess” estimate. Scenarios (such as best, worst, or most likely case) for each input variable are chosen and the results recorded.By contrast, Monte Carlo simulations sample probability distribution for each variable to produce hundreds or thousands of possible outcomes.

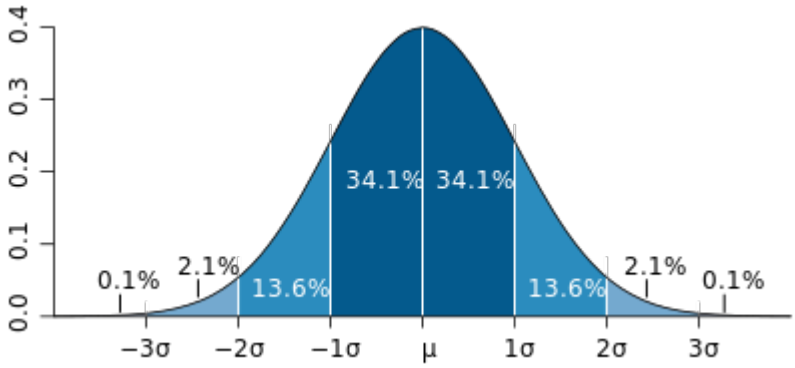


Figure 6. The normal distribution graph

The probability density function (pdf) of the normal distribution, also called Gaussian or "bell curve”, the most important continuous random distribution. As notated on the figure, the probabilities of intervals of values correspond to the area under the curve.

The results are analyzed to get probabilities of different outcomes occurring. For example, a comparison of a spreadsheet cost construction model run using traditional [9]“what if” scenarios, and then run again with Monte Carlo simulation and Triangular probability distributions shows that the Monte Carlo analysis has a narrower range than the “what if” analysis. This is because the “what if” analysis gives equal weight to all scenarios , while Monte Carlo method hardly samples in the very low probability regions. The samples in such regions are called "rare events".{wikipedia} From this results can analyzed to determine flexibility valuation for biomass power plant investment. To choose the best option for investment.

Configuration of Monte Carlo Simulation

Uncertainty index such as variable of fuel price Formal Consumption Consumer Price Index Amount of fuel supply , which affects the amount of fuel used in production. Including investment To find information and data is provided for the distribution of information. In order to configure the simulation . Some information is limited to information such as the fuel source for a data mismatch. It may be that this research may have some discrepancy . Finding the distribution of a data set can be found from the formula.

Standard deviation formula $S.D. = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}}$ (1)

Average formula $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ (2)

11.Assumption of Research

This research to determine future investments. It must be assumed values. To adopt a decision which consists .

1) The assumption of the cash flow model [7].

Project (Project Life) 20 years, the cost of operation (Operating Expense: OPEX) costs. In maintenance 0.5 % of the machines per year and special maintenance every 10 year in rated 5 % of the machines price per year. The other expenses including labor Adjusted are followed by inflation increased about an average of[4] 2.85 % per discount rate. The WACC (Weighted Average Cost Of Capital) of this study is 8.51% . The depreciation of building are deducted straight line type 15-year and the equipment depreciation are deducted straight line type 10-year.Tax rate (TAX) will determine[5] (From Year 9) at rate 20 % .corncob fuel price 500 baht per ton and napier grass 300 baht per ton.The rate of fuel costs increase 3.87 % per year [calculated] .Revenue per unit Power purchase rate (1-7 year) 3.392 baht per unit revenue per unit . (From Year 8) 2.892 baht per unit

Power purchase rate = the basis of electric **(**time of use:TOU) + the power variation (Float Time :FT)

2) The assumption of Monte Carlo Simulation

The deviation of Normal Distribution

	Equipment Price (MB)					Change rate (%)		
Capacity (KW)	1000	500 KW 2 plants	500 KW	350 KW 2 plants and 300 KW 1 plant	350 KW 1 plant	Vatiable electric value (Ft)	Fuel change rate	Consumption Consumer Price Index
Average	52.9600	55.0000	30.000	60.0000	22.0000	2.4800	3.8700	2.8400

Deviation	1.2177	5.4314	1.3434	1.0714	1.1661	0.0921	0.0039	2.1400

Table 2. Data of Normal Distribution

At this time the study area has no planting Napier grass so this study is conducted comparing the fuel corncobs.

The deviation of Inverse Gaussian Distribution :Invgauss

	Construction Price (MB)				
Capacity (KW)	1000	500 KW 2 plants	500 KW	350 KW 2 plants and 300 KW 1 plant	350 KW
Maximum Value	5.6000	6.0300	3.1400	6.0200	2.8400
Minimum Value	5.3500	5.9600	2.9300	5.1400	2.7000
Standard Deviation	0.0900	0.0289	0.0851	0.3704	0.0539

Table 3. Data of lnvgauss Distribution

12.Alternative fuels used in the project.

Corncob

There is a seasonality.In the first year, farmers have planted 2 periods per year.The time of period is about 4 months.And then must to plant new generation.Farmers in this area mostly have career maize crop.Present this area has a lot of corncop but in the future may be to high risk about fuel management because uncertainty of quantity and demand of corncob. This fuel investor must depend on farmer.

Napier Grass[6]

Napier Grass can plant all season.Once plant can harvest although 6-7 years[8] .Period of plant is about 4 months.This plant can sprout up.Harvest is about 3-4 times per year.This project must additional investment. In this fuel investor must compensate to farmer 15,000 bath per rai as present don't have farmer to plant napier grass by commercial and this fuel has low risk by fuel management because investor can manage quantity of fuel by themselves because investors are owner of this fuel.

Description	Corncob	Corn Stalk	Napier grass
Fixed Carbon	13.68%	8.14%	14.12%
Volatile Matter	45.42%	46.46%	75.05%
Nitrogen	0.12%	0.13%	6.36%
Ash	0.90%	3.70%	4.14%
Lower heating value (Kj/Kg)	9,615	9,830	13,321
Higher heating value (Kj/Kg)	11,298	11,704	17,505
Source of data	EFE	EFE	Venggan

Table 4. Comparison nutrient of biomass fuel to combustion

Remark : EFE is Energy for Environment Foundation
Venggan is Name of source research napier grass at venggan

This research study initial investment part such as price of machine and equipment in biomass power plant multi-feedstock gasification type,price of power plant construction,changing rate of corncob price for deviation of price involve changing of Consumption Consumer Price Index to investment.

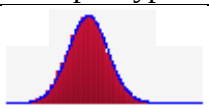
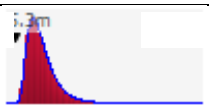
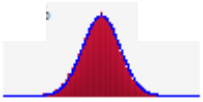
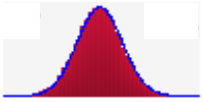
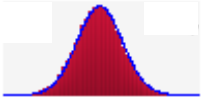
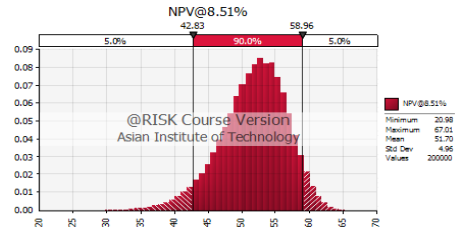
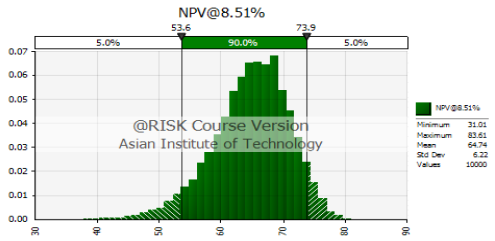
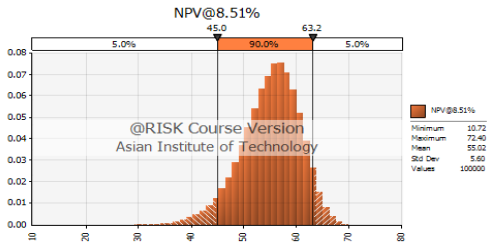
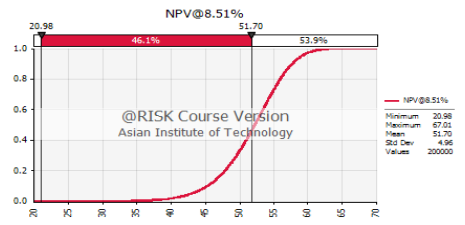
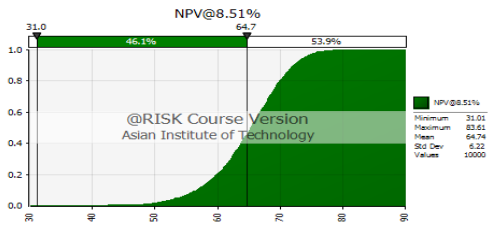
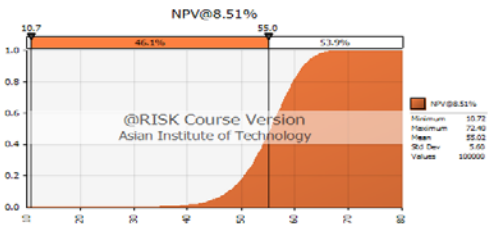
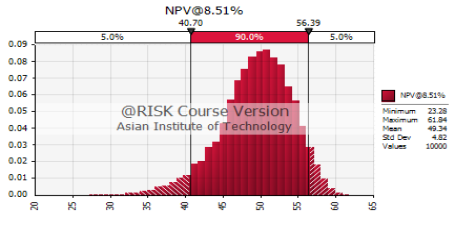
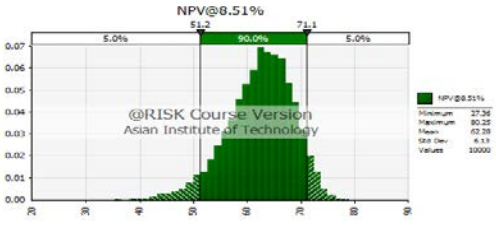
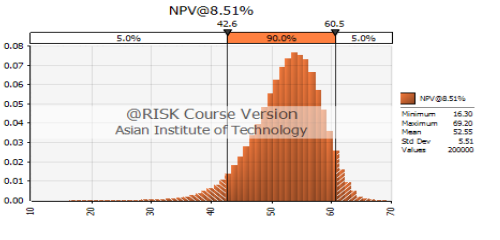
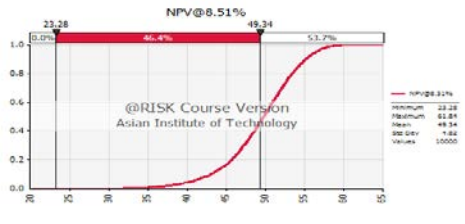
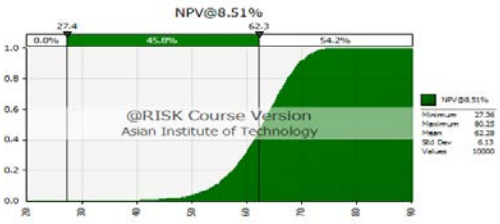
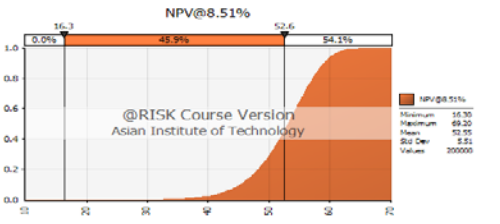
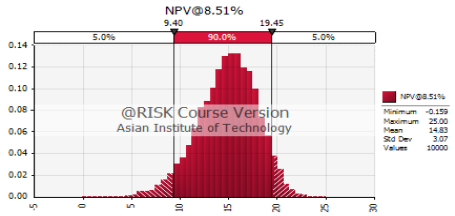
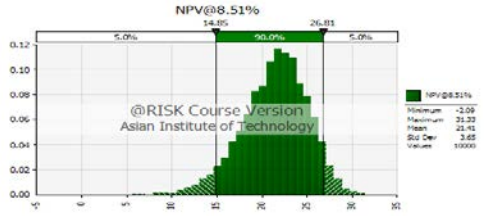
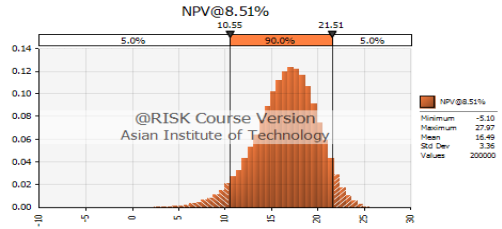
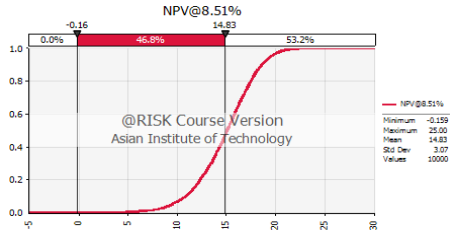
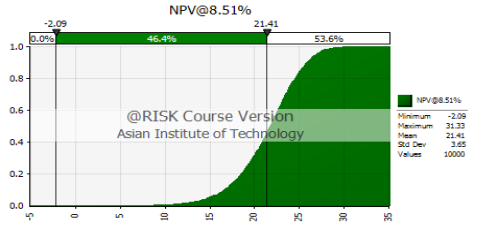
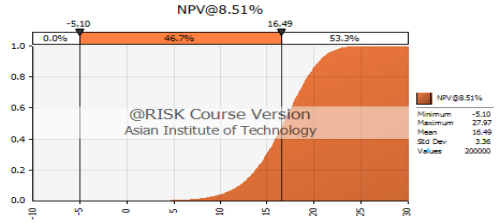
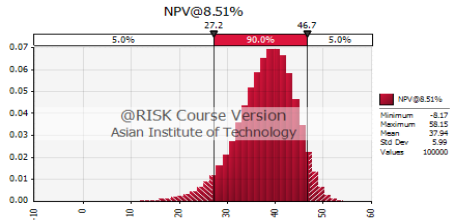
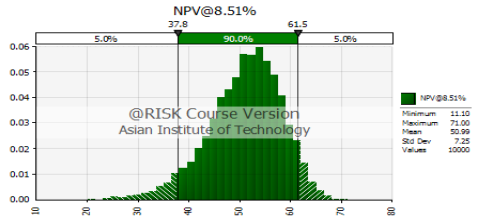
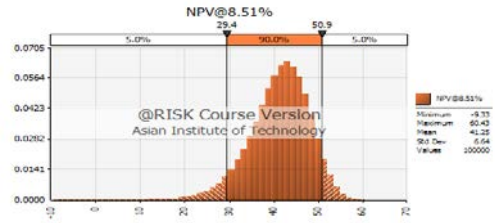
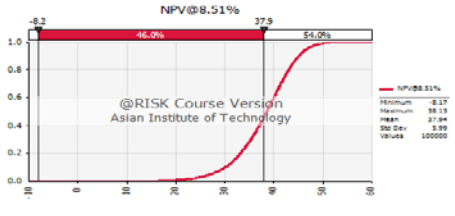
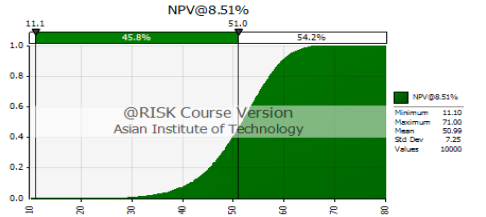
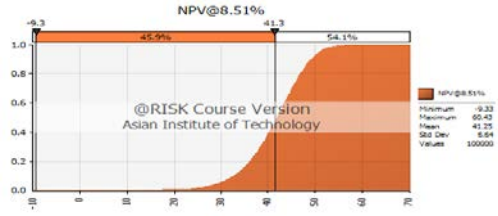
Factors	Graph Type	Graph Name	Configuration
Equipment Prices (CAPEX)		Normal Distribution	Determine to bidding equipment and machine price from 5 contractors to find deviation and average of data because this factors so uncertainty.
Construction Prices (CAPEX)		Invgauss	Determine to bidding Construction Prices from 5 contractors because this investment happened in initial investment.
Value changes Ft rate (Revenue)		Normal Distribution	Because Ft rate has uncerntainty rated so determine deviation of Ft rate from compare value between the previous time and present.
Consumption Consumer Price Index (OPEX)		Normal Distribution	This value had changed uncerntainty so determine deviation from the previous data duration 2002 to July 2013.
The rate of change in fuel prices (Corncob and Napier Grass)		Normal Distribution	The rate of change in fuel prices of some event in each year has very high price but some year has very low price dependent on quantity of production.This phenomenon is found deviation of risk .

Table 5. Graphs defining characteristic distribution of various factors.

13.Analysis and simulation results.

Monte Carlo simulations. The value shows the distribution of the net present value (NPV) that is likely to occur. Which indicates the risk level and which alternative has small distribution of NPV that low risk.

Capacity	Results from Monte Carlo Simulation		
	Corncob	Napier Grass	Corncon and Napier Grass
1000 KW			
			
500 KW 2 plants			
			

Capacity	Results from Monte Carlo Simulation		
	Corncob	Napier Grass	Corncon and Napier Grass
500 KW			
			
350 KW 2 plants			
			

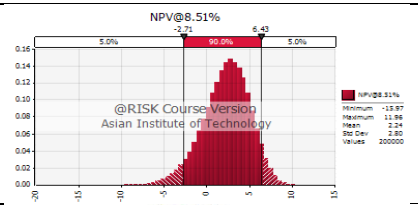
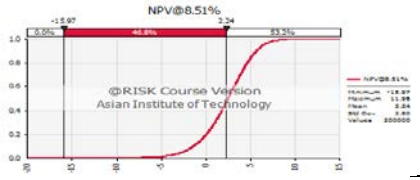
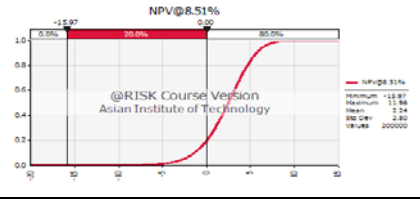
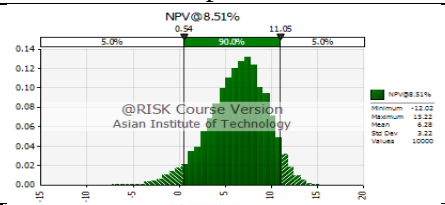
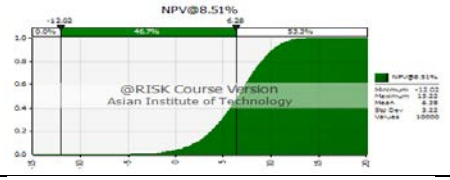
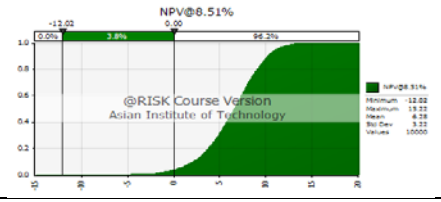
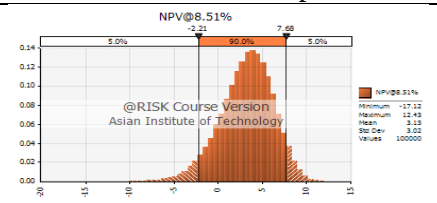
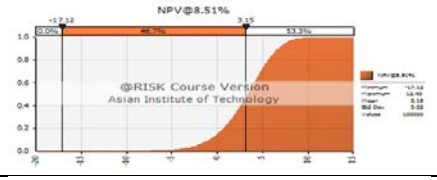
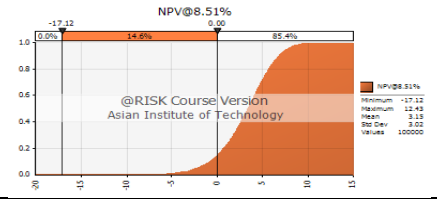
Capacity	Results from Monte Carlo Simulation		
	Corncob	Napier Grass	Corncon and Napier Grass
350 KW	  	  	  

Table 6. Results from Monte Carlo Simulation

Capacity Investment	Capital (CAPEX) MB	Fuel Type	Outcome (NPV) DCF Model (MB)	(IRR) %	Standard Deviation (S.D)	Opportunity of NPV≤0 (%)	Risk Arrangement
1000 KW	64.70	Corncob	52.16	20.47	4.96	NO	2
		Napier Grass	65.33	22.71	6.22	NO	6
		Corncob & Napier Grass	55.53	21.04	5.60	NO	4
500 KW 2 plants	67.20	Corncob	49.73	19.52	4.82	NO	1
		Napier Grass	62.90	21.70	6.13	NO	5
		Corncob & Napier Grass	53.11	20.07	5.51	NO	3
500 KW	39.20	Corncob	15.18	14.49	3.07	LESS	8
		Napier Grass	21.77	16.59	3.65	LESS	9
		Corncob & Napier Grass	16.82	15.87	3.36	LESS	10
350 KW 2 plants and 300 KW 1 plant	72.00	Corncob	38.21	16.60	5.99	LESS	11
		Napier Grass	51.38	18.78	7.25	NO	7
		Corncob & Napier Grass	41.59	17.16	6.62	LESS	12
350 KW	30.95	Corncob	2.50	9.83	2.80	-20.00	15
		Napier Grass	6.59	11.78	3.22	-3.80	13
		Corncob & Napier Grass	3.44	10.29	3.02	-14.60	14

Table 7. Risk Arrangement

Normally risk assessment[10] will determine from probability more than 0 and **Table 7** shows opportunity of return less than 0 which can assess from Value At Risk(VAR) in area under the curve at area under zero line like project B **(Figure 4).**

Analysis the results from Monte Carlo Simulation divided 2 alternatives.

First alternative,NPV less than 0 assess probability from return in area less than 0.

Second alternative,NPV more than 0 will assess deviation of NPV

From this results the investment in powerplant capacity 350 KW by corncob have less deviation but deviation graph shows NPV less than 0 about 20% so the risk in this alternative more other capacitys because distribution graph shows the probability of return more average has opportunity occurred more return less average of NPV so this project can invest but must to be manage fuel but investment in this capacity is easier to supply fuel because use a little fuel while compare with other capacitys.In case investors can fuel management by themselves should be use napier grass only get increase return.The investment in capacity 500KW 2 plants by corncob fuel is the lowest risk compared to powerplant investment 1000KW by corncob because investment in 2 alternatives is the same capacity but deviation of NPV in powerplant investment 1000KW is more so high risk therefore risk management in powerplant should consider factors both financial and fuel management together.

14.Discussion

1.Company case studies, pricing, fuel moisture corn purchased 25% to 500 baht per ton of the study did not research the humidity on the fuel price. This value is used as the base fuel. But making an adjustment for changes in fuel prices instead of managing fuel to be used in the manufacturing process is very important. Even with fuel purchase contracts with farmers. But it also has a very high risk

2.The difference in fuel prices in each area. Make the assessment by financial criteria required calculations are complex. Affect the determination of the distribution of the fuel, which is crucial to the analysis model. The analysis results may be inaccurate.

15.Conclusion

The results from 2 approach.Powerplant investment 350KW by corncob is high risk financial return than investing in other capacitys because high cost (high CAPEX) but low return and graph simulation partial of return less than 0 and powerplant investment 500KW 2 plants low risk financial return than investing in other capacitys.Powerplant investment should consider both financial and fuel management together.Investors should own fuel themselves without relying on others which make it easy to manage biomass powerplant and higher returns

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Biography

Miss Apakorn Pantuwachrapol
Date Birth 21 June 1979
Address 39/9 Rimsuan village 2 Prachauthid Rd. Thungkru Bangkok 10140

Education

1999-2002	Bachelor degree	King Mongkut University of Technology Thonburi
2012-2014	Master degree	Chulalongkorn University

Small River Management in Sustainable Rural Development:
From Engineering Theory to Practice in Local-Scale Water Resource Management

Michel Soto Chalhoub[1], Ph.D, P.E., S.E.

Notre Dame University

Abstract

Water resource engineering management is vital to environmental sustainability in developing countries, especially when it comes to rural development. Water-related civil projects and corresponding policy issues are typically addressed at a macro level, often remaining theoretical with limited applications that actually reach the end-user or beneficiary community. While there are several reasons for this lack of application including technical, political, and economic barriers, the present paper narrows the analysis to issues related to community-level engineering considerations, but relates them to policy and economic aspects that could be developed and led by local communities.

We propose a theoretical framework that links the civil engineering perspective to policy and economic dimensions for water resource management in rural communities using small rivers. We discuss the need to move from traditional open channel flow engineering theory to a practical approach that is more representative of small river behavior. The theoretical framework is then tested with an empirical analysis of data collected in village communities in Mount Lebanon, an area known for its natural resources that are not utilized efficiently.

The empirical model defines a dependent variable as a composite index about water project success in terms of local community benefits. Four independent variables are defined as (1) the extent to which local communities would contribute to the engineering management and maintenance of such facilities, (2) the ability to use project output for power supply, (3) the potential use for agricultural purposes, and (4) local community amenability and support for the privatization of such civil engineering works.

We found that the project success index has a statistically significant and positive relationship with the extent to which outputs would be utilized for power supply and for agricultural use. It was also found to have a significant and positive relationship with local community involvement in engineering project success. Results also showed that although there is great anticipation about having such public works led by private parties, there are however question marks about whether the public sector would facilitate such solutions or thwart them. The statistical regression analysis yielded a negative correlation for privatization with respect to the engineering project index.

Another challenge encountered in parallel with this study is the rural exodus of qualified human resources, to urban areas within the country, and to outside the country. This challenge was noted but left for future research, as it entails broader public policy analysis.

Introduction

[1] Dr. Michel Soto Chalhoub is a licensed P.E. and S.E. in the State of California, and ASCE member. He teaches at Notre Dame University and is active in industry, on Code development committees and in natural resource management. He provides expertise in solid and fluid dynamics, urban and rural sustainable development, with applications to quality in engineering program management. He holds a Ph.D. in civil engineering from the University of California, Berkeley, and a Master in Public Policy from Harvard University with concentration in international development and business-government.

Several developing countries lack water resource management policies and public awareness. Various reasons behind this deficit have been identified in research literature. Many attribute this lack of water resource management to poor technical means or engineering solutions in terms of capturing flows running back to the sea (Brikké and Bredero, 2003). Others attribute this missed opportunity to an engineering project management failure (Davis and Brikké, 1995). Yet other researchers see the water supply issue in rural development as a politically motivated agenda at a community, national, and regional level (Mollinga, 2008; NADC, 2004). Many issues identified for water mismanagement in developing countries are common to developed countries as well.

Another trend that is becoming prevalent is the harnessing of ground water in lieu of extending effort in managing surface water and runoff (Seibert et al., 2010). Research has shown that this tendency is motivated by economic and environmental reasons. Some of these reasons include pollution of surface water, drought periods for surface water flow and decreasing river flow in general due to various climatic developments (Burke, 2002; NADC, 2004).

In this paper, we present a framework that considers three main dimensions driving water resource management in the context of rural development in village communities: the *engineering* dimension, the *social and community* dimension, and the *economic* dimension. In a proposed theoretical framework, we address the interrelationship among these three dimensions then provide a regression analysis that links the three dimensions based on empirical data.

Analysis of Water Management Issues

While it has been common to correlate engineering and water resource management issues with developing country status, there are many common issues faced in both developing and developed countries alike (Vörösmarty et al., 2004; EEA, 2003). The perception of water as a free resource, its undervaluation, the realization that water problems are community-based, and the fragmentation in water resource management, are present in both developed and developing countries (Morris et al., 2003). These factors pose challenges in water resource engineering and management projects at a global level (WWAP, 2006).

Water as a free yet expensive commodity

There is a longstanding view that water is a free commodity that has influenced habits of water use in various parts of the world (Chartres et al., 2010). Although this view exists about less developed countries, the challenge of water undervaluation is also faced by developed countries. The view of a broken pipe in the street causing water to flow to waste, unattended for extended periods of time, is a common scene in both developed and developing countries (VWD, 2013). At the same time, inhabitants would be purchasing containers to cater to their daily water needs. This paradoxical image has a serious undergirding from an engineering economics perspective. The free rider concept applies to this phenomenon as it entails engineering and public works that no one is entitled nor interested in performing (Cornes and Sandler, 1994). Why would the individual bear the cost singlehandedly to generate social benefits to a community? In Nevada, for example, not-for-profit agencies fulfill the role of water conservation (VWD, 2013). In West Midlands, UK, authorities assign the responsibility to the private owner for water conservation and reporting water wasted through leaks (SSW, 2013). In late 2013, in Detroit, Michigan, millions of gallons of water went to waste in unattended facilities (Williams, 2013). A 1921 study showed that Detroit, a city that is historically known for being at the forefront of mechanical engineering, civil systems, and water distribution networks, leaked over 2.5 million gallons per day, of which 56% were caused by broken mains and joint leaks (Fenkell, 1921). In Lebanon, three prices are periodically paid by end users for water usage. A price is paid to the government as a lump sum for a yearly subscription. Another price is paid to private parties – typically small vendors – that supply water containers delivered to various local communities. Yet another price is paid to

companies that sell drinking water and supply fountains to residential and commercial facilities. Empirical data collected in Lebanon shed light on several attitudinal features including the triple-price effects (Chalhoub, 2010).

Water as a communal responsibility

Work performed by international development organizations showed that many water management responsibilities are shifting from central government to local communities (WaterAid, 2011). The motivation behind this shift is that most problems identified were related to soil erosion, water loss, and local conflicts, all of which are community-related (Cleveringa et al., 2004; Neef et al., 2004). Similar initiatives are being implemented in developed countries where reliance on state and local government for water resource management is shifted to local communities (WaterAid, 2013; SSW 2013). Some of the challenges are related to the willingness of public sectors to relinquish control, and private parties to be amenable to the idea of transferring water service provision to non-governmental parties (Neef and Heyd, 2004; Bunclark et al., 2011).

Research performed on international development programs on water resource management in developing countries concluded that local community involvement - and even local project leadership - is a key success factor (Balland and Plateau, 1996; Wade 1988). Research on communal responsibility showed the importance of community involvement in tackling and solving such problems. Local community management in water engineering issues requires the establishment of local public policies. The Global Environment Facility (GEF) that jointly implemented with the United Nations Development Programme (UNDP) local community empowerment programs in Ghana, Guatemala, Kenya, Mauritania, Sri Lanka, Uganda, and Tanzania, concluded that for such public policies to succeed, local organizational structures need to be established ranging from local village water committees to quality reporting and auditing bodies (GEF, 2012).

Water resource management as a fragmented responsibility

The absence of a focal public body that handles the water management value chain has been identified as a major weakness in water resource management (Anderson, 1983). This feature is not only specific to less developed countries, but exists in the most technologically advanced and preservation policy-sensitive nations (Lubell and Edelenbos, 2013; Levin et al. 2002). In the USA for example, water supply and flood control is managed by the US Corps of Engineers and the Bureau of Reclamation. The USA Fish & Wildlife Service is responsible for the water-dependent sporting and related species. The Environmental Protection Agency (EPA) is responsible for water quality in general, and the proliferation of chemicals (US EPA, 2005). There are, in addition, a slew of other state-level environmental agencies that work with EPA on those issues at a state and local government level (Karr, 1991; Shih et al. 2006).

For the reasons above, there is a need to establish methods of managing a closed cycle on water resources engagements that include rivers with coordination among engineering projects, social and community priorities, and economic feasibility (Hassing, 2009). River basin management became a global concern to put limits on pollution, coordinate engineering design and execution, especially when rivers cross from an upstream country to another downstream country (Rahaman and Varis, 2005). Interestingly, the issue of responsibility fragmentation becomes more complex in trans-boundary collaboration on river waters where the integration of responsibilities crosses country borders. One of the examples is the Mekong River, the twelfth longest river in the world, which crosses Laos, Cambodia, Vietnam, and Thailand (Hassing, 2009). Other examples, albeit within the same country, address small rivers where integration is recommended at the river basin level (Hassing, 2009; UNESCO, 2008).

Small Rivers in Rural Areas

Physical Properties, Water Supply, and Ecosystem Support

It would be inadequate to narrow down the role of small rivers to a mere source of water, when in season (Meyer et al., 2003). Small rivers are in fact refuges for ecosystems, many of which are not well understood by their local communities. Small rivers support ecosystems through soil formation, pollination, provision of habitat, population control, and regulation of drought (Kaplan et al., 2008). They also offer cultural features to humans such as recreation, aesthetics, and many non-materialistic values. This feature could be developed into a more thorough discussion on environmental valuation, including existence value (Chalhoub, 2012). However, this broader discussion is left outside the scope of this paper to focus primarily on the functional dimensions set forth in earlier sections.

In populated areas, small rivers are vulnerable to human actions and are subjected to stress levels, depending on the geographic location and enacted environmental protection policies (Wohl, 2006). In Byblos County, Lebanon, small villages house light industries such as the manufacturing of cement masonry units, or stone veneer saws that have deep effects on small river health (Chalhoub, 2012). River health is also influenced by variations in its water temperature. Global warming is causing a net rise in average yearly temperatures in water streams (Döll and Zhang, 2010). Water temperature is also part of small river categorization. According to Conservation Gateway, small rivers are grouped into six categories based on bed slope gradient, water temperature, width, and other engineering properties as shown in table 1 (Conservation Gateway, 2010).

Slope Category	Water Temperature	Description
Low gradient	Cold	Slow moving, marshy terrain, bed dominated by silt, sand, fine gravel, average width 21 m, water of high turbidity and poorly oxygenated, at high elevations
Low gradient	Cool	Same as above, average width 20m, at moderate elevations
Low gradient	Warm	Same as above, average width 19m, at low elevations
Moderate gradient	Cold	Fast moving, rocky terrain, bed dominated by sand, gravel, and cobble, clear water and relatively well-oxygenated, average width 20 m, at high elevations
Moderate gradient	Cool	Same as above, at moderate elevations
Moderate gradient	Warm	Same as above, at moderate to low elevations

Table 1. Small river macrogroups according to Conservation Gateway on North America's Rivers (2010).

The categorization in Table 1 is accompanied by detailed manuals explaining the types of species that exist in each setting, their habitat, and the extent to which they are endangered or affected by human interventions (Conservation Gateway, 2013).

A small river has its own practical engineering peculiarities in terms of width, catchment area, slope, and roughness. In France, 78% of total river length has a width less than 15 meters. In Slovenia, 80% of total river length in the country has a width less than 5 meters, and in Denmark, 75% of total river length has a bed narrower than 2.5 meters (European Commission, 2007). In the U.S. a small river features a catchment area less than 200 km^2, while in Europe a small river features a catchment area less than 100 km^2. In Scotland, 80% of river length in the country has a catchment area less than 10 km^2; in Slovenia 90% (European Commission, 2007; EEA 2012). There is ample evidence worldwide that small rivers form the majority of surface water circulation. Given their vulnerability, lack of visibility, and proximity to localized communities, small rivers require special precautions in terms of environmental protection and resource management (Meyer, 2003).

In Lebanon, small river data documentation is scarce and needed for future research. Secondary data is available from works from the western hemisphere, and from developing countries as planned and implemented by international development organizations. When we turn to local challenges, we draw on such secondary data with adaptation and adoption (EEA 2012; Conservation Gateway, 2013). This is particularly critical because small river management

requires a deep understanding of human activities and their effects on ecosystems (Kremen and Ostfeld, 2005).

Engineered small river structures – pros and cons

Small river engineered dams were initially intended to provide solutions against drought season and power supply deficit in both developed and developing countries (Lewis, 2013). There are about 2 million dams in the US and 80,000 large dams of a height greater than 6 feet. In the US about 500 dams were built per year in the 1980s. At present, the rate is about 300. Dams were built for various reasons including power generation, agriculture support, and recreation as a windfall. For example, the damming of the Colorado River and the Columbia River was accomplished for purposes of farming (USSD, 2013). Other dams were considered as engineering grand works such as the Hoover Dam, which created Lake Mead. Glen Canyon Dam forms Lake Powell on the Colorado River, and is used for hydroelectric generation, water distribution in between years of low and high precipitation, and provision of recreational activities and boating. Therefore, most large dam functions include a significant human entertainment feature and tourism (US Dept. of the Int., 2013). However, dams alike many other human interventions, have been criticized for disrupting the natural equilibrium of ecosystems (Whittaker, 1975; Williams and Wolman, 1984).

To generate hydropower, various alternatives must be considered and selected in favor of the one that would have the lowest environmental impact (Ward and Stanford, 1995). Although dams were generally considered as hydraulic structures with positive communal outcomes, there has been extensive research showing their negative effects. There is a closed dynamic ecological cycle for rivers that is in equilibrium among erosion, sediment transport, sediment deposit, habitat, and temperature. Causing an artificial stagnation of river waters has multiple negative ecological effects (Grant et al., 2003).

When it comes to small river dams, especially the ones that are considered for developing countries, many disadvantages surge. Since the 1960s and with the environmental movement at the time, many researchers addressed the downside of constraining the dynamism of river water. Research has shown that many river flows that were brought down to standstill water no longer support the natural habitat and ecosystem that used to exist around them (Naiman et al., 1995; NRC, 1992). The dynamic nature of river water flow has its own life sustenance system (Allan and Flecker 1993; Karr et al. 1985). Since the integrity of a free-flowing water system depends on the dynamic character of that system, blocking it needs to be well studied from an environmental engineering perspective (Williams et al. 1996). Channel geomorphology and habitat require a detailed environmental impact assessment (Power et al. 1995; Resh et al. 1988). In addition to the dynamic feature effect of the natural flow, its variability through time and location was proven to be an important factor as well (Hughes and Noss 1992). The analysis the effects of thwarting natural flow showed that it is necessary to maintain flow variability to minimize human impact on it, and when restoration occurs, it must follow a protocol to reverse the effects with minimum environmental impact (Stanford et al. 1996; Holling and Meffe 1996). In developing countries, such effects get compounded due the lack of policies and corresponding environmental laws, or for lack of proper enforcement even when such laws exist.

Mathematical Modeling Considerations for Small Rivers as Open Channel Flow

Rationale for a proposed theoretical model

To make calculations possible in open channel flow, engineers use simplifying assumptions related to channel geometry and flow properties (French, 1985). However, the challenges are greater in real life situations in hilly areas where creeks have slopes with high gradients, where river bed bents frequent, and where natural terrain is weedy and exhibits high frictional resistance at the river bottom. Therefore steady state flow formulas do not apply in areas where it takes

several days and often weeks to build up the flow rate following water seepage in dry soil. Following the dry season, the river re-establishes its bed in the rainy or snow-melting season in parallel with a cycle of weed and sediment transport (Chalhoub, 2013).

Channel cross-sectional shapes can be reasonably modeled and controlled in human-made canals. In most other cases, the shape is a result of the works of nature. Rectangular and trapezoidal sections are commonly used in open channel computations. But in the field, a variety of random channel sectional shapes are encountered. This phenomenon becomes more complicated when the shape at a given station changes through time due to erosion in one reach and fill in another reach. The slope is another variable that changes frequently in small rural rivers. This is especially complicated in the presence of boulders and other irregularities on the river bed (Yalin, 1992).

The seasonality of small rivers complicates the set of assumptions used in the computations of river flow rates. We propose that the roughness coefficient, generally denoted by *n*, cannot be assumed to be a constant for a given river bed material as tabulated in most open channel flow literature (Manning, 1891). The resistance coefficient is rather a function of total flow rate Q and of small river meander (Chalhoub, 2013).

Mathematical Model

We express the total flow rate as a function of river cross sectional area A, hydraulic radius R_h, river bed slope S, and roughness coefficient *n*, we have:

$$Q = \frac{1}{n}\ A\ R_h^p\, S^r \qquad (1)$$

where *p* and *r* are power exponents determined through experimental and analytical techniques. Manning found that for commonly used channel sections, an estimate of *p = 2/3* and *r = 1/2* provided a reasonable match with scaled laboratory results (Manning, 1891). However, we shall consider *p* and *r* in their general form, and *n* as a function of depth *y*. Using the definition of the hydraulic radius, and denoting by *w* the river width, expression (1) can be written as:

$$n\,(y) = \frac{w^{p+1}}{Q}\ S^r\, y \left[\frac{y}{w + 2\,y}\right]^p \qquad (2)$$

The variation in *n(y)* for two streams of comparable widths and conveying similar flow rates is expressed as the partial derivative in *y*:

$$\frac{\partial n\,(y)}{\partial y} = K_{w,Q}\ \left[\frac{y}{w+2y}\right]^p + p\ y\ \left[\frac{y}{w+2y}\right]^{p-1}\left[\frac{w}{(w+2y)^2}\right] \qquad (3)$$

where $K_{w,Q}$ is a function of river width and average flow. In the expression of the gradient in *n*, we introduce three basic assumptions. The first one is that small river flows are shallow. The rippling effects are observed on the water free surface which is directly influenced by the geometry of the river bottom. The second assumption is that the small river has a variable bed configuration at any given control section. This is particularly pronounced for rivers that run on seasons and present a low or null flow when out of season. The third assumption is that small rivers, by virtue of their locations, have frequent meandering. The detailed mathematical derivation is left outside the scope of this paper. We present partial results to illustrate the

correction factors required for small rivers over classical theories that apply to less rugged open channel beds (Chalhoub, 2013). Defining a function $f\ (\partial n/\partial y)$ that includes the simplifications performed on the gradient of *n*, we perform an integral over the depth of the river to obtain the adjusted roughness coefficient *n**:

$$n^* = \int_0^{y_{max}} f\ (\partial n(y)/\partial y)\ dy = \left[1 + \frac{\Delta n\ (\%)}{100}\right] n \qquad (4)$$

We present part of the results that illustrate adjustment factors to *n* as a function of flow depth for a given river width. For a river width *w* = 20 meters (m), the simulation model shows that *n* should be adjusted by 35% for a flow depth of 0.10 m, diminishing to 10% for a flow depth of 2 m. The adjustment percentage in the range of 35% corresponds to relatively meager depths. This result is in agreement with physical field observations as rippled shallow waters flowing in the depth range of 0.1 to 0.2 m have to overcome a larger relative roughness than a flow of say 2 m in depth (figure 1). The direction of the adjustments is in agreement with pipe flow theories that define *e/D* where *e* is the irregularity on the interior surface of the pipe, or pipe roughness, and *D* is the clear interior pipe diameter. Similar results were reached in a simulation for a river width of 19 m with flow depth varying between 0.05 m and 3 m. Adjustments to *n* in this case range from a high of 37% down to a low of 9% (figure 2).

The simulation data can be cast into a simplified formula by finding an exponential trend function for a given case. For the case of *w* = 20 m and a depth varying between 0.05 m and 2 m, we can express the adjustment over *n* as a function of depth at a particular control section along a given river reach:

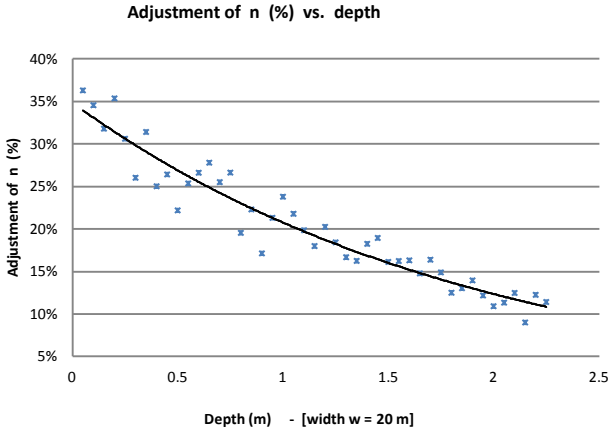


Figure 1. Percent adjustment to the roughness coefficient as a function of flow depth (w = 20m).

$$\frac{\Delta n\ (\%)}{100} = 0.3484\ e^{-0.518\ d} \qquad (5)$$

where $\Delta n\ (\%)$ is the adjustment percentage and *d* is the flow depth in meters. Due to field-related error margins, we consider that expression (5) may be used for neighboring values of river bed width. Similarly, we develop an exponential trend function for *w* = 19 m which is given in expression (6):

$$\frac{\Delta n\ (\%)}{100} = 0.3893\ e^{-0.46\ d} \qquad (6)$$

These results also demonstrate that small rivers require a set of adjusted formulas of their own that

tale into consideration their meandering nature, the variability in their cross sectional shape, and their seasonality (Chalhoub, 2013). River bed coefficients that are typically tabulated in literature and used for open channel flow may underestimate the roughness of a meandering small river and therefore may cause an overly optimistic estimation of the flow carried by its stream. Such an overestimation of water flow has many implications on project planning and rural development expected outcomes.

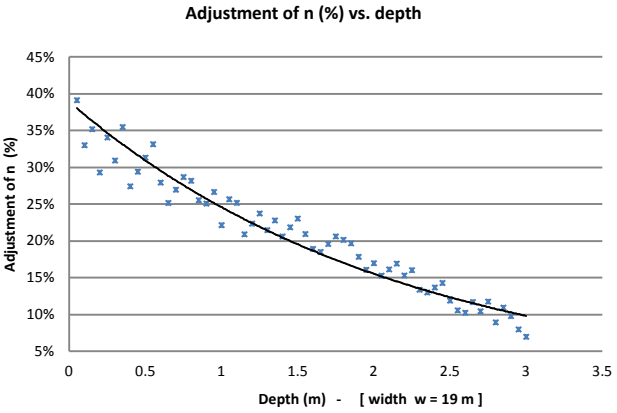
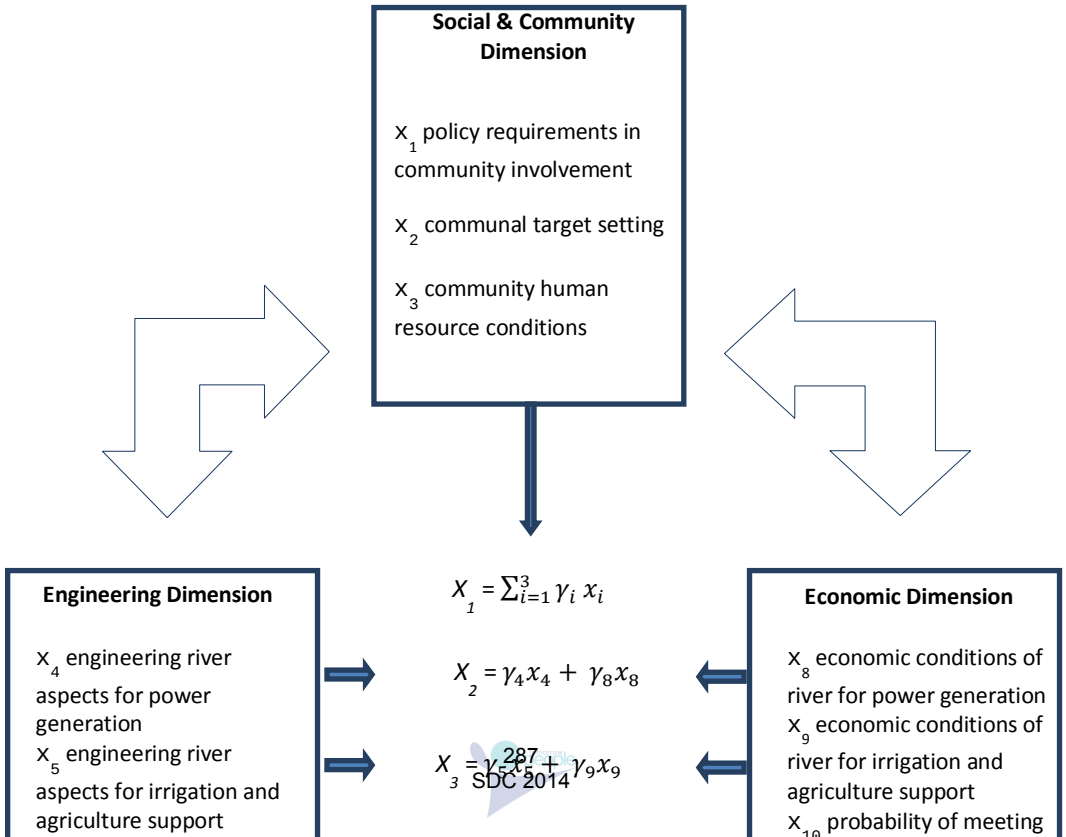


Figure 2. Percent adjustment to the roughness coefficient as a function of flow depth (w = 19 m)

Theoretical Framework: Engineering, Community, and Economic Dimensions

Framework Development

Having discussed water resource engineering and management issues, we introduce a theoretical framework that links the *engineering* dimension, the *social and community* dimension, and the *economic* dimension. The theoretical framework shown in figure 3 is tested in the following sections using empirical data by performing a regression analysis. The theoretical framework includes eleven variables related to a rural development project over a small river. From the preceding analysis of water issues, no theoretical engineering solution can be implemented unless the other two dimensions – social and economic – are actively managed. We also demonstrated in the previous section that engineering solutions based on open channel flow theory may yield optimistic results leading to a mismatch between expected and actual results, whether for hydropower generation or irrigation civil projects, potentially causing water stress (WBC, 2006).



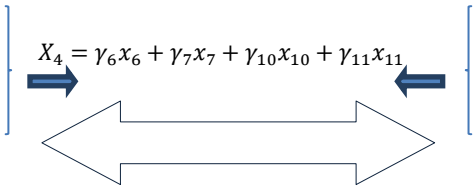


Figure 3. Theoretical framework linking the engineering dimension to the social and community dimension and the economic dimension.

The variables x_1 through x_{11} were collected on a Likert scale. These are used in a linear combination with coefficients γi to determine the independent variables X_1 through X_4 used in the regression equation. The rationale behind these variables is to capture, along with the engineering and technical aspects of the rural development project, the attitudinal aspects and predisposition of the community to perform according to guiding principles in water resource management.

Discussion of the Variables

In earlier sections, we discussed policy implications on the *social and community* dimensions and emphasized the importance of a clear public policy in creating a social network around water use and management. This variable is represented by x_1. The second variable, x_2, represents the importance of target setting in communities to rally the effort around clear objectives for water use. The third variable x_3 relates to the availability of human resources. The challenge faced in Mount Lebanon is its brain drain as many respondents commented during our exploratory research phase that the departure of human resource has been irreversible.

For the engineering component, variable x_4 addresses the view of the community with respect to the use of a small river for power generation, while x_5 addresses the use of the river for irrigation and agricultural applications. Variables x_6 and x_7 also address the engineering dimension whereby they represent meeting engineering targets and the amenability to let private entities manage the project, respectively. Variables x_8 and x_9 pertain to the economic dimension related to using the river for power generation and agriculture, respectively. The economic feasibility and the amenability to let private parties handle the economic side of the civil project are represented by x_{10} and x_{11} respectively.

With the first level variables defined above, the theoretical framework in figure 3 provides a roadmap for the relationships among those eleven variables distributed across the three main dimensions. One of the challenges faced with such frameworks is that they expect the end-user to have an understanding of engineering, managerial, and privatization concepts. That was not the case with many respondents. For example, a challenge was faced with the criteria related to amenability to privatization. Many respondents were not clearly in tune with the concepts, implications, and repercussions of privatization. Further, there may have been a predisposition due to the local Lebanese culture of being biased in favor of taking the helm of public service management in private hands.

Numerical Application of the Theoretical Framework

Empirical Model

The theoretical framework was tested empirically based on a regression analysis. We define the dependent variable Y as an index that represents the ability of local communities to handle water resource civil engineering projects.

We define the first independent variable and denote it by X_1 to represent the extent to which the local community would contribute to the operation and maintenance of the facility. The

representation of X_1 in the regression equation uses data related to x_1, x_2, and x_3, combined from their respective Likert scale into a weighted average where the weights are denoted by γ_i where i is the number of the variable under consideration.

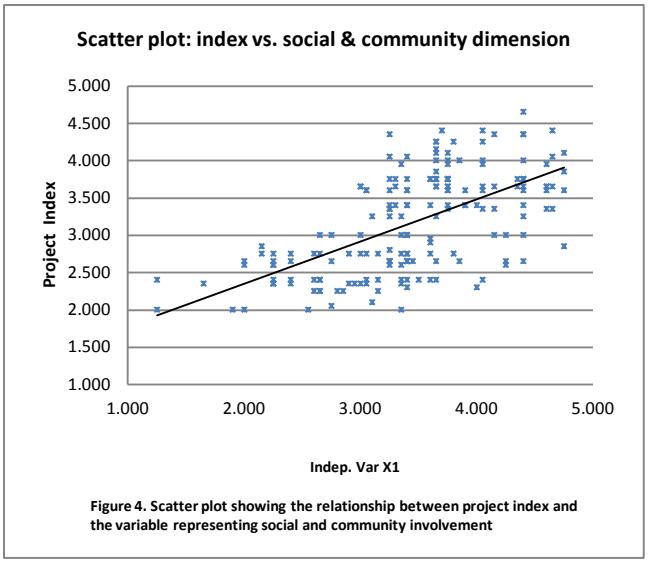


Figure 4. Scatter plot showing the relationship between project index and the variable representing social and community involvement

Numerous examples exist about water resource project failures directly attributed to the lack of community involvement (UNDP, 2006). Research has even suggested environmental activism as a feature that is becoming a necessity in many developing countries (Gross et al., 2001). Activism relies on the fact that projects fail if there is not one pro-actively pursuing their project targets (WHO, 2008).

The second independent variable is defined as X_2, which represents the community readiness and ability to harness project output towards power generation. Variables x_4 and x_8 are used in a weighted average to define X_2. In Lebanon, the lack of power supply from the central government is nowadays substituted by local generators. These local generators require fuel burning and cause air pollution, hazard, and cost above what is paid to the electric utility company. Some of the municipalities gave an incentive for residents to stop using private generators and to rely on a single power station led by their municipality. The marginal benefit is therefore the aggregate unused energy by individual households.

The third independent variable X_3 represents the potential use for agricultural purposes. This item requires further study because of the nature of agriculture common in the geographic areas where we conducted research. The villages in Byblos County that are in the middle strip between 450 and 700 meters of altitude are populated with trees that do not require persistent irrigation such as olives, almonds, and some fruit trees (Chalhoub, 2013). Most of the region does not rely on human-made irrigation for older olive or almond trees. Irrigation in the empirical model was therefore linked to plantations that require periodic irrigation. Commercial operations such as the ones that use greenhouses were left for future research to focus on community development in its most basic sense as it relates to households and the livelihood of families.

The fourth independent variable X_4 focused on the extent to which the local community sees privatization of water projects as a viable solution. This particular variable could be the object of extensive future research under separate scope. Privatization, in general, and for water resource management in particular, is still a subject of debate among engineers, public works officials, and policy analysts (Posel, 2012). It has been applied to major civil engineering projects in water resources through agreements between mega construction companies, local governments, and funding parties such as global banks (McIntosh and Yniguez, 2000; Shiva, 2000). Privatization policies especially in civil engineering water supply projects were at the same time praised and criticized. Critics of the privatization of public works in civil engineering argue that water belongs to public goods just like air, security, and safety. While those who support its privatization argue that a private party generating profit would be working under an incentive to continually provide and improve services and get feedback from the citizen as a customer (Hayes, 2003). In the context of small river engineering management, it is not customary to privatize services but it could be explored given its localized effect.

The dependent variable denoted by Y can be expressed as a function of the four independent variables:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + o(X) \quad (7)$$

where β_0 is the intercept and β_i ($i = 1, \ldots, 4$) are the regression coefficients, plus an error term. Regression computations result in regression coefficients and their corresponding standard errors. These computed values help determine the statistical significance of each independent variable in defining the dependent variable, and whether correlation is positive or negative.

Discussion of results

We point at some features of the scatter diagrams showing the relationship between *Y* and two of the independent variables. The data plot of (Y, X_1) exhibits some clustering at the high end of the Likert scale, showing that the relationship between *Y* and X_1 is predominantly in the 4-5 range which is primarily favorable to community involvement. The scatter between *Y* and X_3 is sparse and exhibits a spread in the responses related to the use of small rivers for irrigation and agricultural purposes. The overall results from the multilivariate regression analysis can be summarized in expression (8):

$$Y = 0.2175\ X_1 + 0.3734\ X_2 + 0.4685\ X_3 - 0.1025\ X_4 \quad (8)$$

$se_1 = 0.0393$	$se_2 = 0.0355$	$se_3 = 0.0346$	$se_4 = 0.0275$
$\gamma_1 = 0.35$	$\gamma_4 = 0.65$	$\gamma_5 = 0.655$	$\gamma_6 = 0.35$
$\gamma_2 = 0.25$	$\gamma_8 = 0.35$	$\gamma_9 = 0.345$	$\gamma_7 = 0.15$
$\gamma_3 = 0.40$			$\gamma_{10} = 0.35$
			$\gamma_{11} = 0.15$

Equation (8) has an r^2 value of 0.9. Results from the multivariate regression analysis show a positive and significant correlation between the project index and the independent variable X_1 representing community involvement in river-related civil engineering projects. The relationship is statistically significant at $\alpha = 5\%$ significance level, and as the standard error value se_1 for the coefficient β_1 is 0.0393 < 0.05. This is in agreement with most *ex-post* studies performed on the importance of local community involvement and management in sustainable rural development as discussed in earlier sections. There is a positive and statistically significant relationship with the potential use of the river for power generation and for agricultural use as their regression coefficients are β_2= 0.3734 and β_3 = 0.3685, respectively, and their standard error values are se_2 0.0355 and se_3 0.0346, respectively, and both smaller than $\alpha = 0.05$. This result is also consistent with past studies with the exception that, as stated in earlier sections, the communities under study did not exhibit awareness about the potential negative effects of human intervention such as erecting small dams or creating parallel catchment basins as

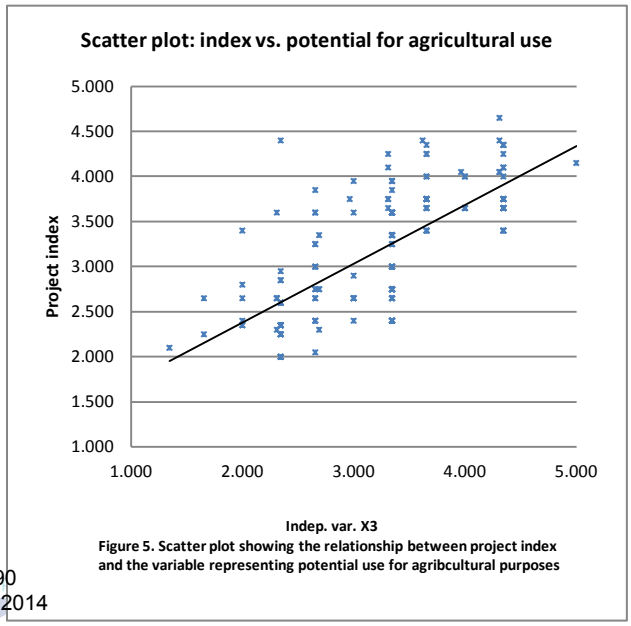


Figure 5. Scatter plot showing the relationship between project index and the variable representing potential use for agribcultural purposes

documented in other regions of the world. In those regions, small river civil projects have come full circle from planning, to execution, to dismantling dams. Nevertheless, we still consider the results for X_2 and X_3 indicative of potential solutions that could be sensitive to environmental concerns, and still more suitable than letting the water flow back to the sea without any exploitation.

The correlation with the independent variable X_4 representing amenability of local communities to the privatization of civil works on small rivers was found statistically significant but negatively correlated with project index. This can be seen from the standard coefficient error of $0.0275 < 0.05$ with a coefficient of -0.1025. This point requires further investigation in future research where we recommend that education and awareness-building in the form of town meetings and workshops be provided about privatization, its benefits, and its drawbacks. It is our belief that an educational program about the use of small rivers preceding a more detailed sequel to the present research would certainly shed light on engineering technology options, and result in a target audience that is more in tune with these options.

Conclusions

With the importance of water resources in all aspects of sustenance and development, and with disconcerting effects from direct human interventions and global climate change, attention is turning to the harnessing of headwater and upstream rivers branches in addition to traditional facilities on the main river arteries. This trend is most felt in rural development by virtue of the location of creeks and small rivers, and their intertwined path within local communities. Human interventions through dams on small rivers have productive effects but may be counterbalanced by a larger negative environmental impact. Challenges exist because water is undervalued, communities are still not in tune with the criticality of their roles in getting involved and leading small river projects, and responsibilities are fragmented in terms of water resource management.

Another set of challenges exists from an engineering perspective because most theories developed and used to-date use simplifying assumptions that are better suitable for large rivers than for small ones. Since there are fundamental differences between a large and a small river in terms of bed geometry, reach curvature, and bed bottom composition, fundamental adjustments need to be applied to traditional open channel formulas. A discussion of open channel theory shows that the application of commonly acknowledged formulas may lead to an underestimation of roughness and meandering of a small river and may lead to overly optimistic results. Further, these engineering findings require a link to broader, more practical outlook at the relationship among the engineering dimension, the social and community dimension, and the economic dimension. From an engineering economics perspective, challenges exist because water is undervalued and often wasted. A dilemma exists in considering water as a public good just like air and security, versus putting it in private hands where managerial incentives are better delineated.

A proposed framework links the three dimensions above. It is tested with a numerical model based on regression analysis. Small river project success index is found to be significantly and positively related to the extent to which small communities are willing to get involved in civil works and subsequent engineering management, to the potential of using the river for hydroelectric power, and to the potential of using the project for irrigation. The index is negatively correlated with the extent to which local communities are amenable to the privatization of such projects.

In the course of this research, a lack of awareness was observed among respondents about the pros and cons of privatizing civil engineering works. Another finding was related to the exodus of human resources from rural areas, which was described as irreversible. Both of these points were left for future research.

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Solid Waste management, New Methodology for Determining Solid Dump sites by Using Remote Sensing data and GIS

Prof. Mohamad Rukieh

General Director of AAFAQ Establishment for trading and consulting

E-mail rukiehm@gmail.com

Syria – Damascus – Mazeh – P.O.Box 9916

Abstract:

The Arab Cities produce more than 300 thousand tons of solid waste per day, most of them end to makeshift dumps. Within this frame one of the basic tasks in the management of these wastes is to determine the optimum place to bury and processed it, is an essential matter due to their negative effects on the environment.

The remote sensing data and GIS play a very important role in these studies, due to the wide and comprehensive view, which these techniques can provide, and their possibility to connect the whole factors which contribute in the determination of such sites.
We carried out in Syria many studies about the mentioned subject. I used the integration methodology between office and field works, the integration of spatial data interpretation and the traditional ones with the GIS, for nine stages of work, this leads to preparing a group of thematic schemes or maps which contribute in determining the optimum sites of the sanitary landfill or dump, the most important are:
-. Contours scheme.
- Transportation and settlements scheme.
- Lithological scheme.
- Water drainage system scheme.
- Scheme for the wells in the studied areas and their water level.
- Groundwater movement scheme.
- Soil classification scheme.
- Geomorphologic scheme.
- Geological scheme.
- Land use scheme.
- The final determination scheme for the site.

Linking between these schemes within the GIS and the program of the optimum determination of the site for the environmental and economical facilities which has been designed in GORS, as well as giving the suitable ratio to each factor, can contribute in determining the sanitary landfill or dump site in any place of the studies areas. We pointed out as case study for this methodology to Homs landfill.
Key Words: Remote sensing, GIS, solid waste, thematic schemes,

I- Introduction

This research aimed at explaining the methodology used by us in studying the sanitary landfills and solid waste dumps through determining the factors and criterions which affect it by using resent techniques such as remote sensing techniques, GIS, GPS, and other different software which help in determining the ideal locations for landfills, taking into consideration the different environmental impacts of them.

II- Definition of landfill site:

A safe sanitary landfill is an engineered pool, constructed in land, or on land surface to be filled with wastes to avoid hydrological contact between wastes and surround environment especially ground water.

There are four essential elements which should be taken into consideration for the landfill safety: - Landfill's inside cover. - Accumulation system - Coverage

Normal hydrological state to prevent pollutants leakage to groundwater.

III- Kinds of landfills: There are four kinds of landfills:

- Open dump. - Semi controlled.- Engineered landfill. - Sanitary landfill.

Sanitary landfill is considered a developed stage that differs from other kinds in that wastes in it are pressed and covered by soil daily to reduce negative effects that generate from it, such as bad odors and predate.

IV -The effective factors in determining landfill site:

1- Geological and litho logical factors:

The quality of rocks, their ages and their geological and tectonic position play an important role in determining the landfill site. The more the rocks are in permeable, of high thickness, of horizontal shape, and unaffected with tectonics, fractures, faults, karsts and dissolution the more they are better for site determination.

2- Hydrological and hydro geological factors:

The effect of both surface and groundwater has an essential role in determining the landfill site. Where it is important to study surface drainage system and water sheds, as well as recognizing the movement of surface water and the extent of their penetration towards depth, also it is necessary to recognize aquifers, their thickness, the extent of their influence with surface water, their depth, their movement direction, in addition to study the extent of impermeable rocks existence, and determining the existed wells and their water elements through preparing appropriate schemes using resent techniques.

3- Geomorphologic factors:

The relief's' statue plays positive or negative role in determining landfill site. The area which consists of gentle depressions and hills is good landfill site determination from morphological point of view.

4- Transportation, settlements (their nearness and farness from the landfill) and wind effect:

The landfill site must be far enough from the settlement (at least 1.5 km) in order to protect the environmental safety, taking into consideration the wind direction and its effect. There must be available roads to the landfill site, and the distance between the city and town from which the solid waste are taken and the landfill shouldn't exceed 30-35km.

5- Soils' kind and properties:

The existed soils' kind should be studied besides preparing soil classification scheme to be used in evaluating landfill determination. There are the soils of valleys, plains and the poor soil of hills. The more these soils are poor, of low thickness and unused for agriculture the more they are better for determining the landfill.

6- The manner and kinds of land use:

A land use scheme should be prepared as one of the most important slides for evaluating the landfill determination**.** This scheme should reflect all land use kinds:

The agricultural with all its forms; crops, fruit-trees, forest-trees, forests, grasses….. etc), the industrial with all its kinds, settled buildings, irrigation constructions and their effect, quarrying ,

energy facilities, storehouses, chimneys, industrial wastes, different roads, railways, airports, health houses, artificial amphitheaters effect..etc. In this case remote sensing techniques play the most important role.

7- The required area for the landfill site and its temporal age:

The required area for the landfill site plays an essential role in the determination processes, where it is possible to determine more than one site or place according to the area. The large areas are the most difficult in determining the landfill. We shouldn't forget the study of the environment effect in the processes of landfill determination.

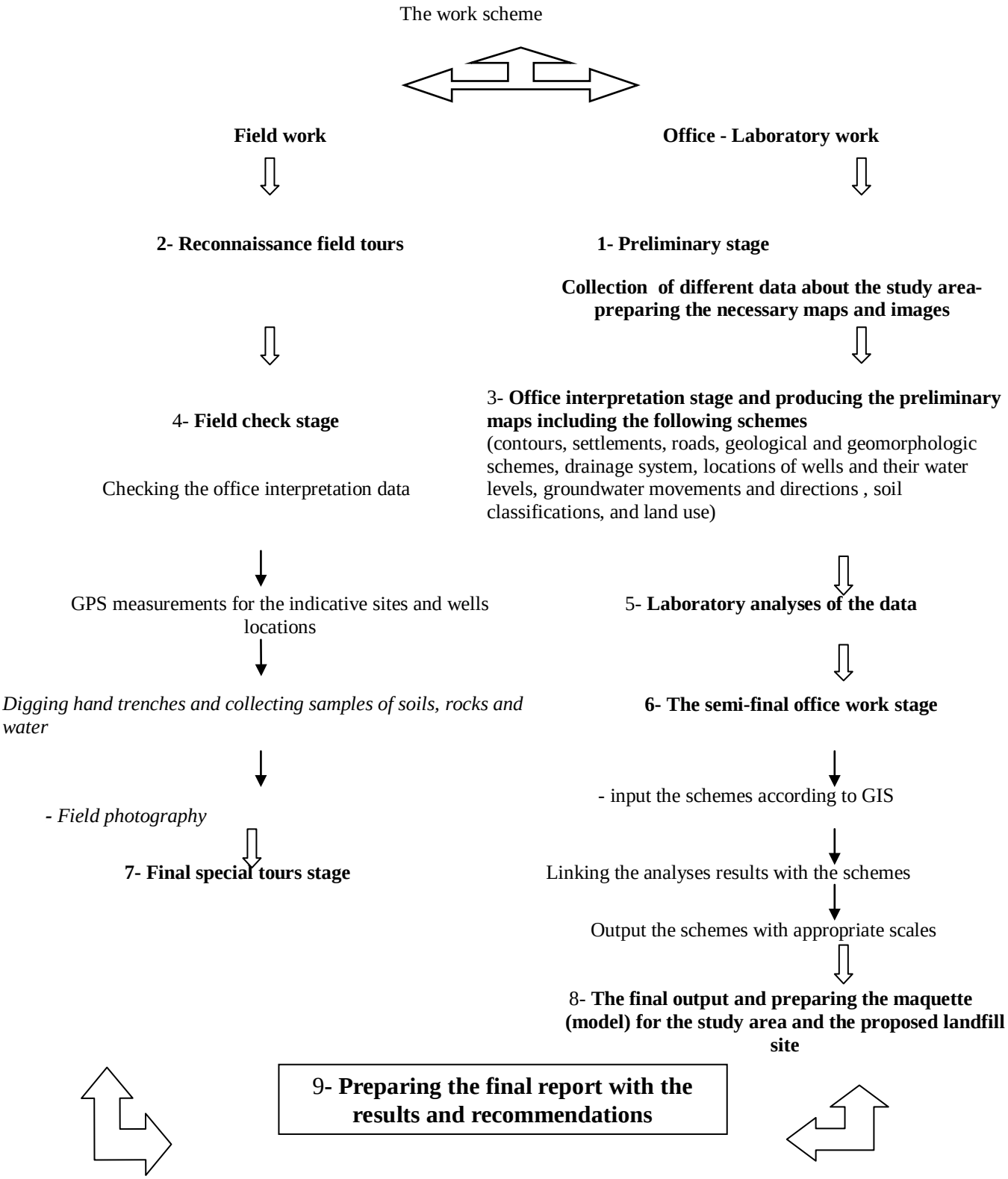
V-The work methodology and its stages:

We followed the methodology of nine steps methods which consist of:

- **Preliminary stage:** in which different data are collected about the study area including space images.
- **Reconnaissance field stage:** in which an acknowledge for nature of the study area is done, in addition to the natural and artificial obstacles, the analysis signs and the changes occurred on the area.
- **Office interpretation for the space images and preparing preliminary maps**: in which preliminary schemes are prepared out of the space data interpretation, in addition to other different data.
- **Field check** stage in which the following are done:
    - Checking the data of space interpretation and preliminary schemes.
    - Taking GPS measurements for the indicative sites and wells locations.
    - Digging hand trenches in the soils and rocks then taking samples from rocks and soils in addition to water samples. Taking field photos.
- Analyzing the samples in labs.
- The semi-final lab or office stage in which the input, output and processing of the semi-final schemes are taken place according to GIS system.

- Final field rounds to determine the landfill site on the land accurately.
- The final layout of schemes and maquette (model) are prepared for the study area.
- Preparing the final report with the results and recommendations.

The following chart symbolizes our work method with its different stages starting from collecting data till preparing the final report.

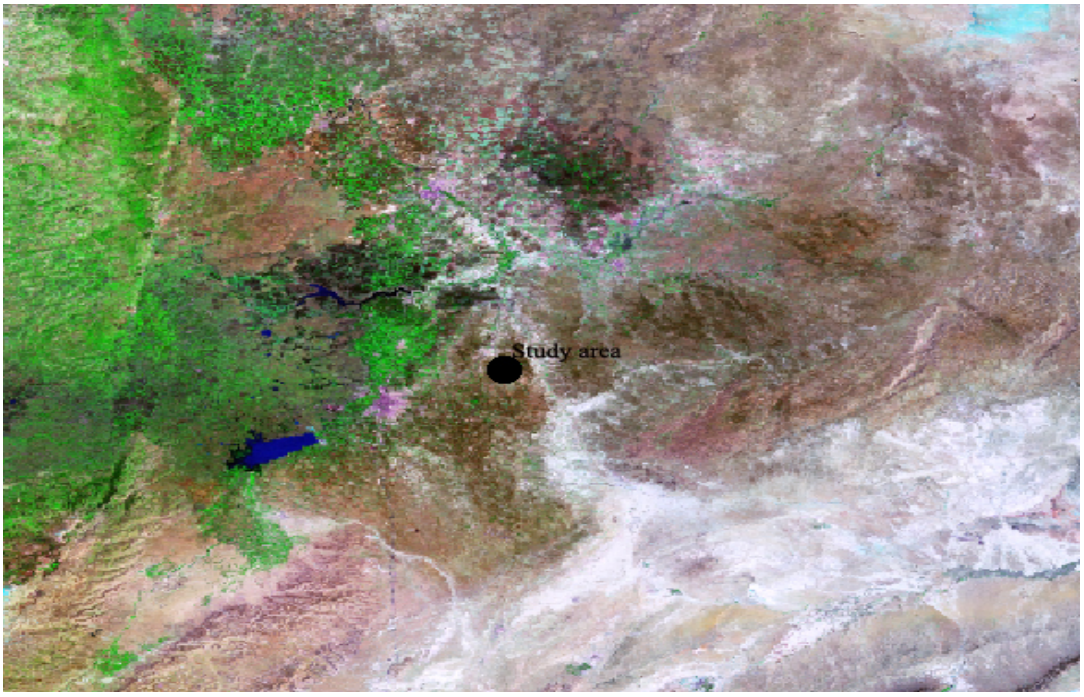


VI-Example on the followed methodology:

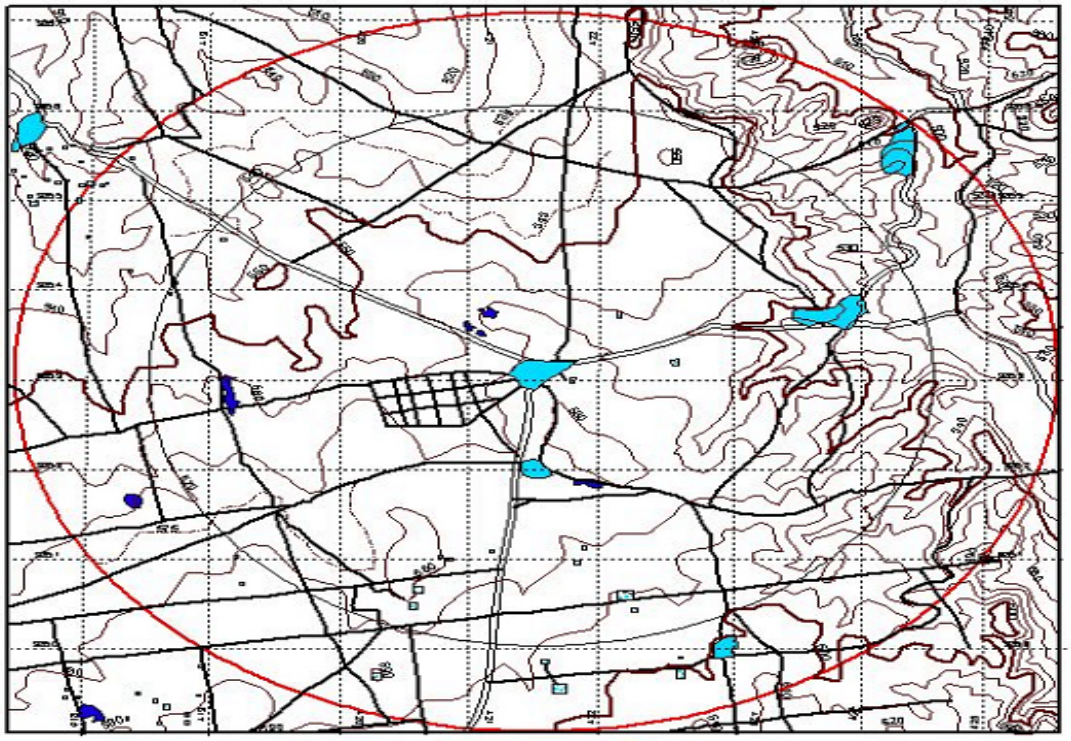
We have followed the mentioned methodology in studying several sites (Rukieh, Alkafri2001, Idris, and Habib 2003-2004); we will refer to one of the studies which we carried out to determine appropriate sanitary landfill to the solid waste in Homs city (Rukieh, Idris 2001). We prepared the following schemes depending on space images interpretation and the available data:

- TM Color space image for study area (Fig.1)
- Contours scheme (Fig.2).
- Transportation and settlement scheme (Fig.3).
- Geological scheme (Fig.4).
- Water drainage system scheme (Fig.5).
- Scheme for the wells in the study area and their water level according to the land and sea surface (Fig.6).
- Groundwater movement scheme (Fig. 7).
- Soil classification scheme (Fig 8)
- Geomorphologic scheme (Fig.9).
- Land use scheme (fig 10)
- Final determination scheme for the site (Fig. 11).

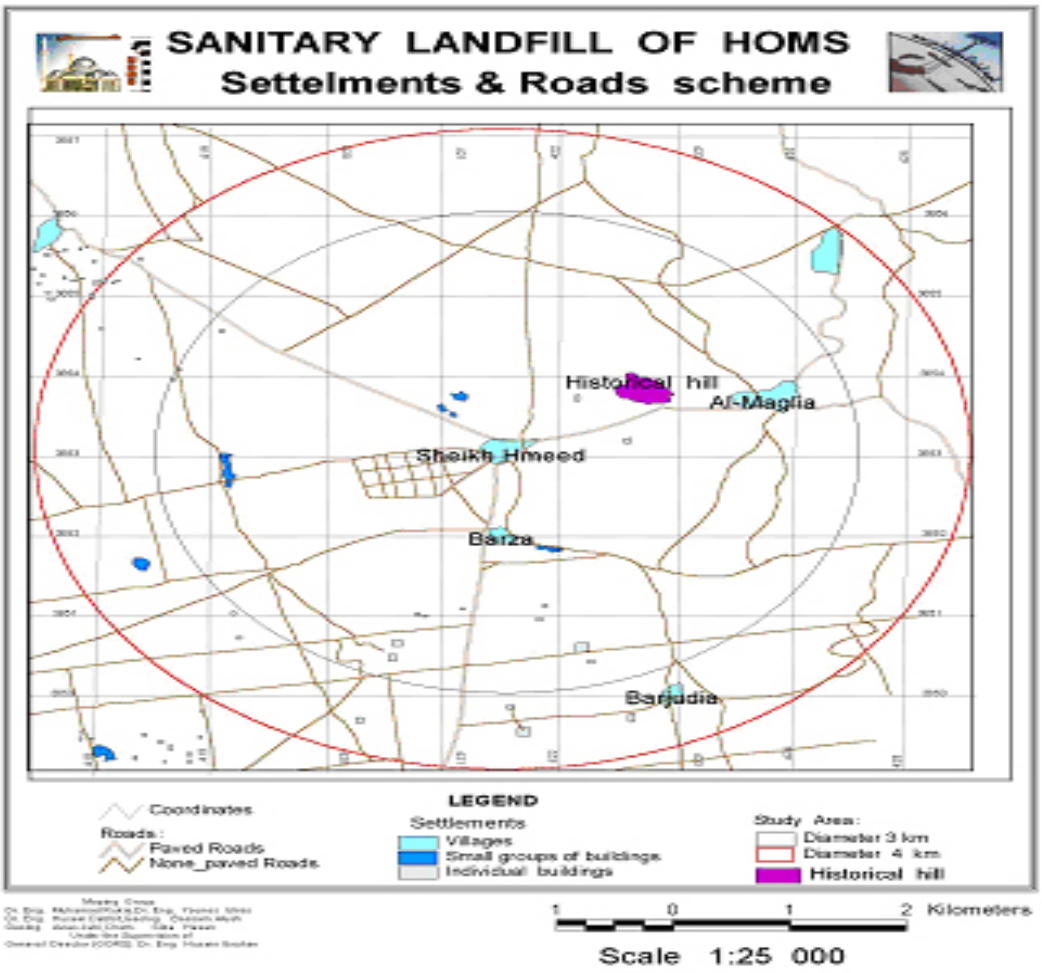
These schemes were linked and entered as slides within GIS system, then the appropriate ratios were given to the different effect on site determination, at last the appropriate landfill site had been determined.



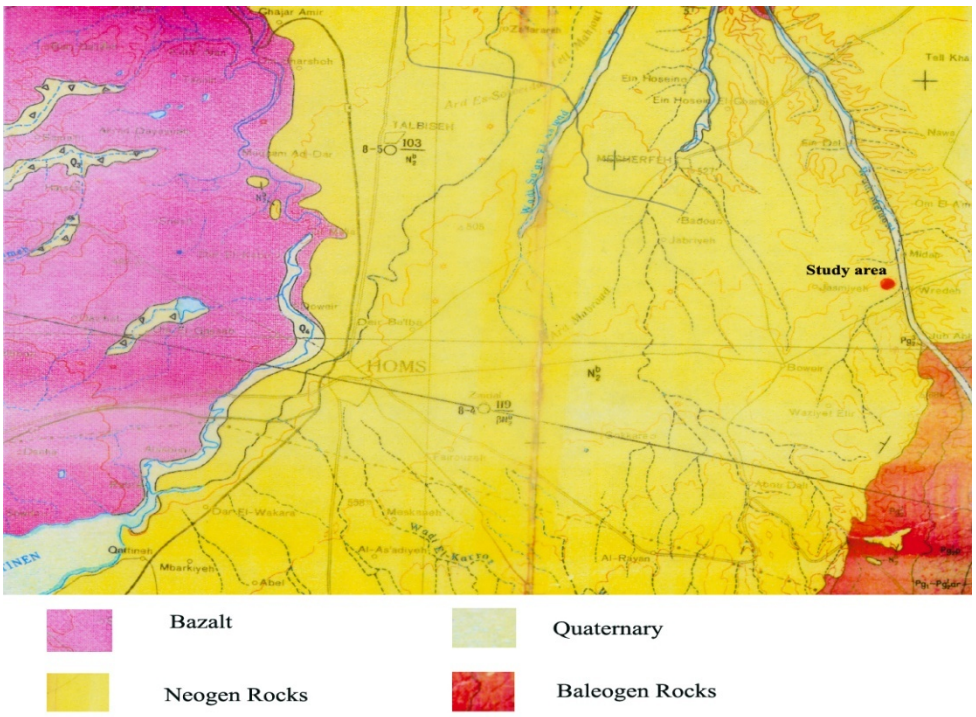
(Fig.1) TM Color space image for study area



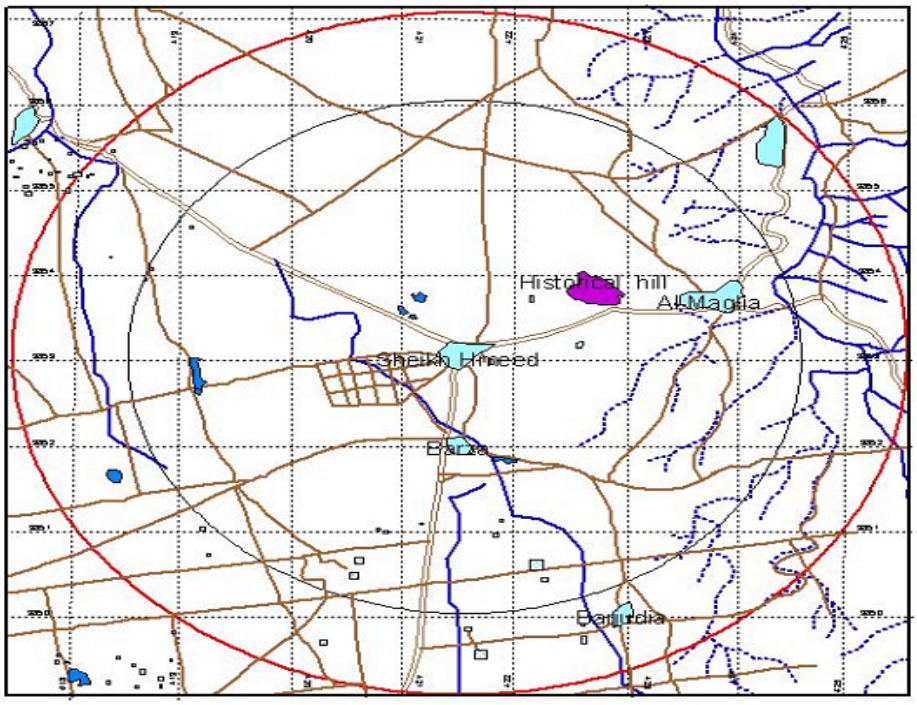
(Fig.2) Contours scheme



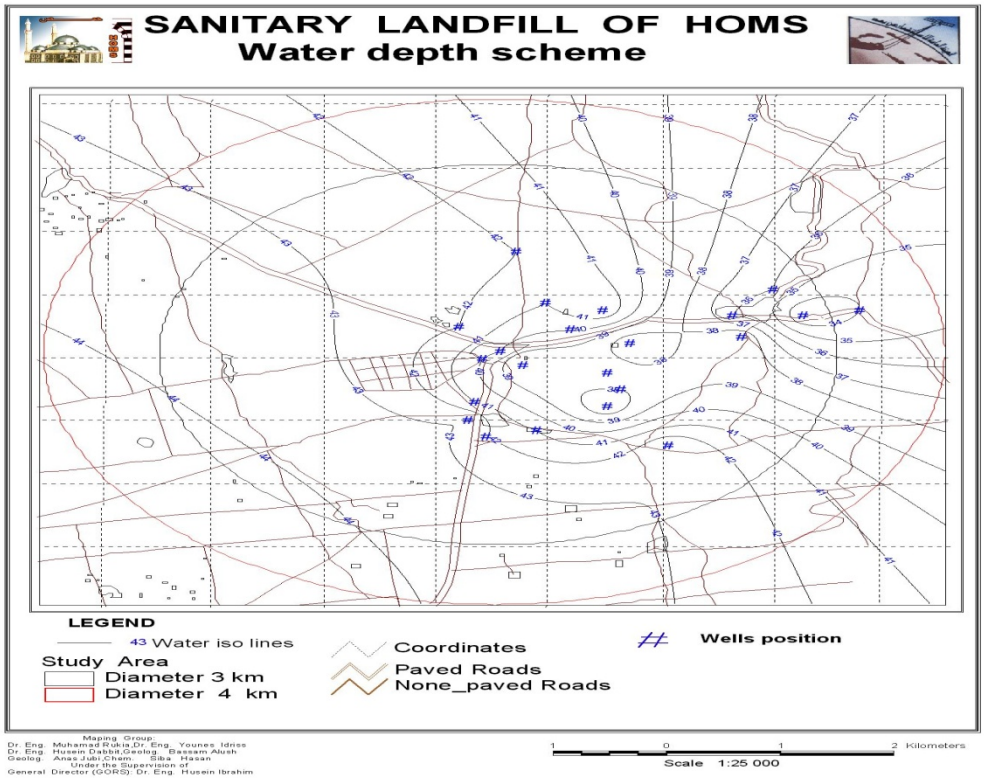
(Fig.3)Transportation and settlement scheme.



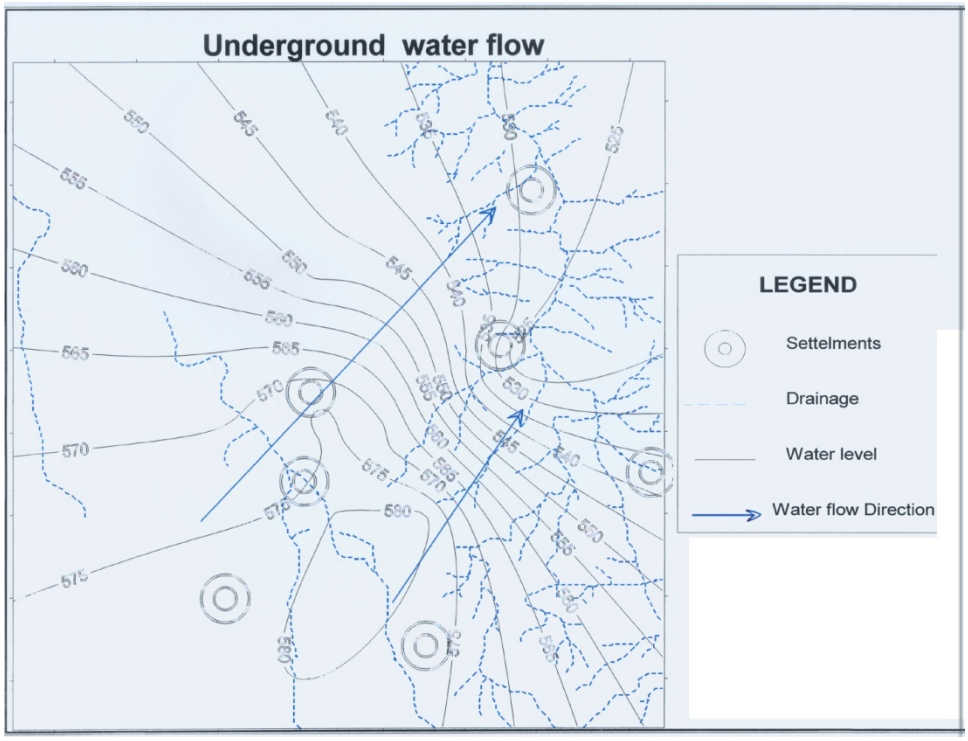
(Fig.4) Geological scheme.



(Fig.5) Water drainage system scheme

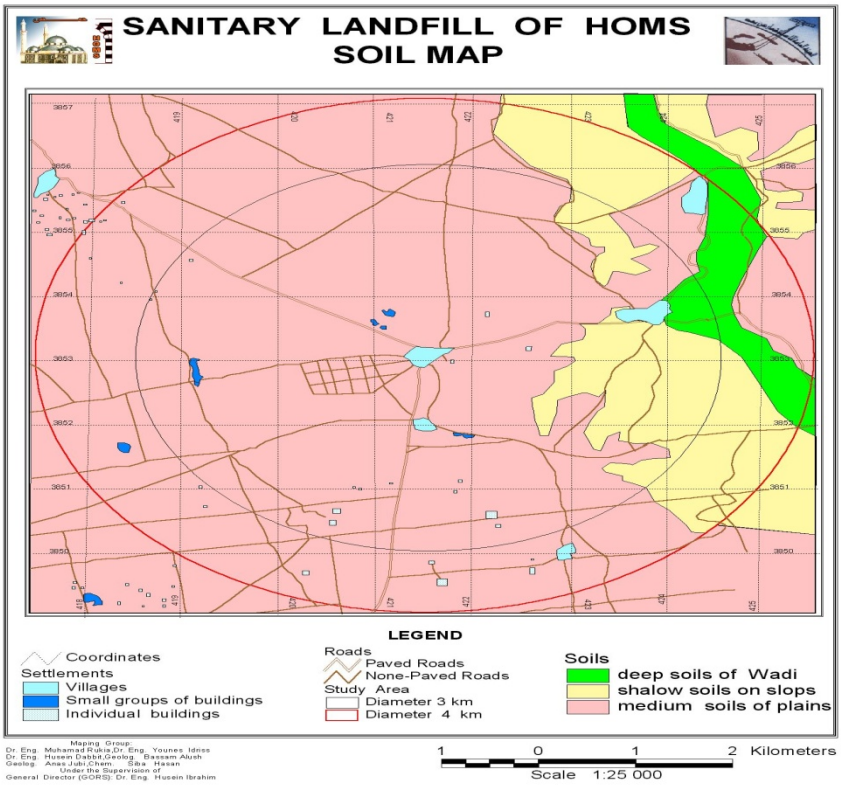


(Fig.6) Scheme for the wells in the study area and their water level according to the land and sea surface

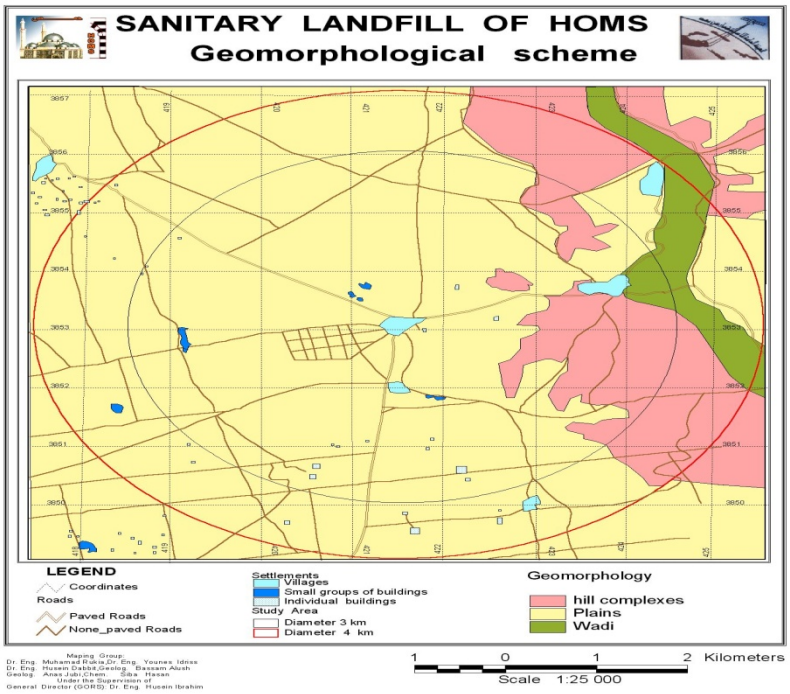


(Fig. 7) Groundwater movement scheme.

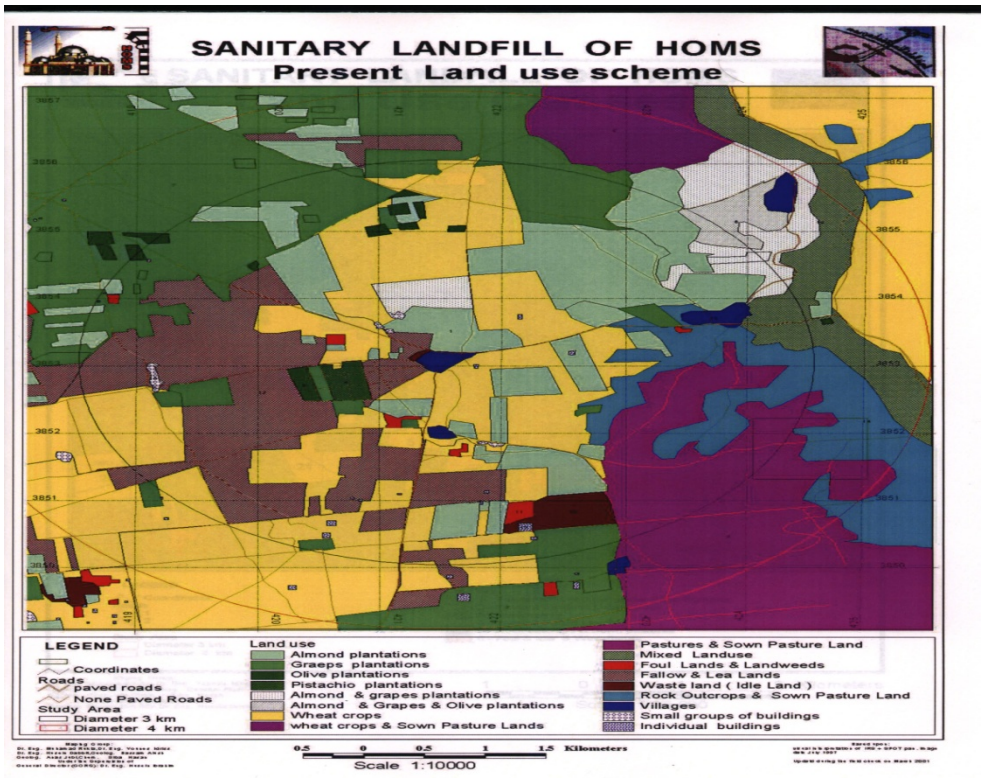
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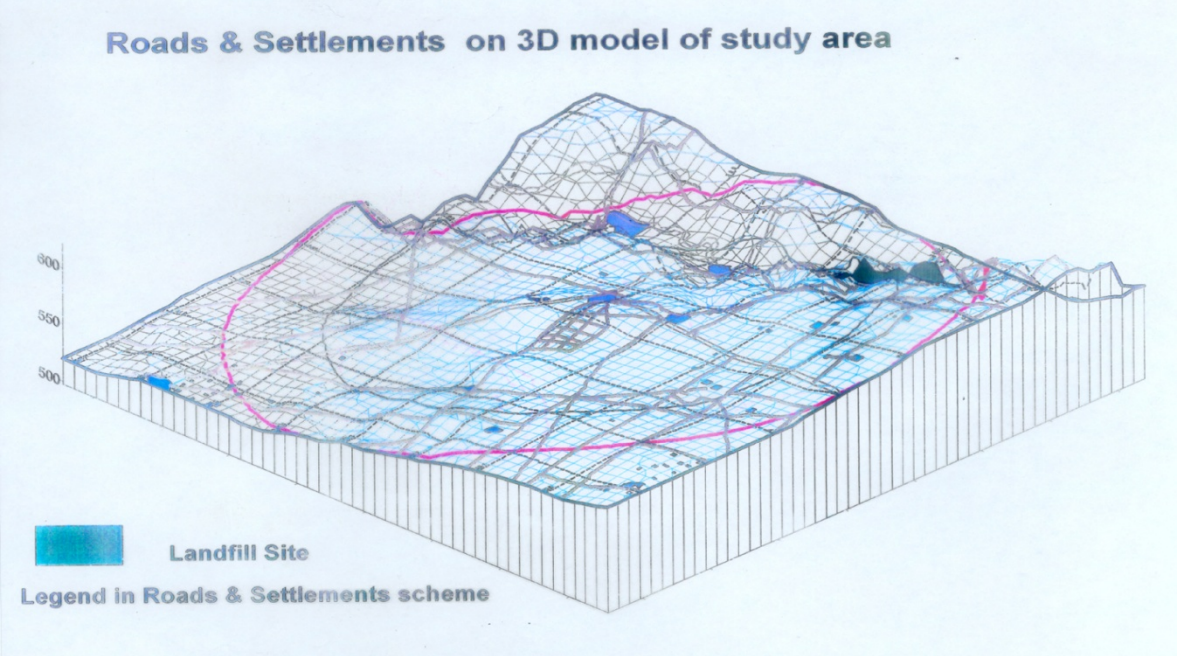
(Fig. 8) Soil scheme



(Fig.9) Geomorphological scheme.



(fig.10) Land use scheme



(Fig. 11) Final determination scheme for the site.

VII -Conclusion:

Using remote sensing and the other related techniques beside the different processing programs in studying and determining sanitary landfill sites and dumps according to the used methodologies can save time and money and provide accurate result which can be used in similar studies.

VIII -References:

1- Rukieh M., Y. Idris et-al, Preliminary Study for Determining The Final Location of the Landfill Site of the Hard Waste in Homs City- Syria, (General Organization of Remote Sensing), Damascus, 2001.

2- Rukieh. M,. Alkafri. A, Joubi. A, Report for determining appropriate site for landfill in Latakia city (Latakia, Jabla, Qurdaha, Al-Haffa), (General Organization of Remote Sensing) Damascus, 2001.

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State-Market-Civil Society Cooperation: Lessons from Farmer Suicide Crisis and Rural Development in India

Chunchen Xu

Abstract

It is estimated that more than 250,000 Indian farmers have committed suicide during a span of 16 years (1995-2011). In 2009 alone 17,638 farmers committed suicide, indicating that one farmer committed suicide every 30 minutes. This paper presumes that Indian farmer suicide crisis is a multifaceted problem symptomatic of a looming agrarian and human rights crisis. The Indian farmers' plight is elucidated in the context of an intricate interplay among public policy, globalization, and culture dynamics. It is argued that civil society has played a salient role in combating this enormous tragedy and that State-Market-Civil Society cooperation is needed in order to formulate integrated approaches to eradicate rural poverty.

This paper first introduces the magnitude, causes and consequences of this epidemic of suicide among Indian farmers, and then explores government intervention, market-based mechanism and civil society approaches respectively, as well as efficacious practices stemming from the State-Market-Civil Society cooperation in remedying Indian rural distress. In addition, the different roles and responsibilities of the state, market and civil society as well as their comparative advantages and disadvantages are also discussed in this paper. Furthermore, a brief comparison between India and China in terms of agriculture and rural development is also included.

Keywords: farmer suicide, India, State-Market-Civil Society cooperation

1. Introduction: Magnitude, Causes and Consequences of Farmer Suicide Crisis in India

Like China, India is an agrarian country with 69.1% of its population s living in rural areas in 2010[1]. In the industrialization process in India, the share of agriculture in GDP in India has been on the decline over the past few decades; in 2010, agriculture only contributed to 18.0% of the overall GDP in India[2]. Nevertheless, because agricultural sector supplies food, raw materials and labor for other economic sectors, it is the foundation for industrial and economic development in India. Like in China, rural development is an essential concern for Indian government.

However, much to the government's dismay, it is estimated that more than 250,000 Indian farmers have committed suicide during a span of 16 years (1995-2011), hence affecting approximate 1.5 million surviving family members; in 2009 alone, 17,638 farmers committed suicide, indicating that one farmer committed suicide every 30 minutes (CHRGJ 2011: 1-3). This appalling tragedy is the largest recorded suicide wave in the history of humans, and should be deemed as a serious crisis of human rights (CHRGJ 2011: 13-21).

To properly estimate the magnitude and scope of this epidemic Indian farmer suicide, two factors must be taken into consideration: firstly, the aggregate number of farmers has been declining significantly with millions of farmers migrating to urban areas and thus leaving behind them "the old, hungry and vulnerable" in the village[3]; secondly, it has been argued that the NCRB (National Crime Records Bureau) has undercounted the actual number

[1] http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS/countries

[2] http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS/countries/1W-IN?display=graph

[3] *See* P. Sainath. "Decadal journeys: debt and despair spur urban growth" *The Hindu*. September 26, 2011.

of incidence of farmer suicides by excluding suicides of women and lower-caste farmers who often do not have title to land and are not recognized as "farmers" (CHRGJ 2011: 9-10).

It is generally agreed that the proximate cause of the farmer suicide crisis is indebtedness, which directly drives numerous farmers to great financial and emotional distress. Facing rising costs of inputs and decreased price of agricultural produce in the global market, farmers often become trapped in a mire of debt and destitution; because Indian agriculture is mainly rain-fed, when natural calamities and lack of access to irrigation lead to continued crop failures and consequently decreased income from the sale of crops, farmers will be unable pay the usurious interest on loans and consequently choose to take on more loans and buy more inputs in hope of a good harvest, which in turn can lead to greater debt. Most ironically, some farmers ended their lives by ingesting the very pesticide they went into debt to purchase (CHRGJ 2011: 9).

Furthermore, it has also been pointed out that the spate of Indian farmer suicide is only the tip of the iceberg. Stating that Indian agricultural system itself is at stake, some experts interpret Indian farmers' plight as indicative of a looming agrarian crisis that stems from a series of economic liberalization policies implemented by Indian government in 1991 (Balamuralidhar 2009; Schuman 2009). Since then the Indian government has urged farmers to switch from food crops to cash crops, withdrawn subsidies for farmers and considerably reduced its investment in the agricultural sector, thus subjecting India's agricultural produce to high levels of price volatility in the global market. In fact, Indian government has long been blamed for its lack of sufficient investment in the agricultural sector and consequently the stagnation of Indian rural areas, thus the Indian government's inaction has further

aggregated the situation (CHRGJ 2011).

In addition, the government's Neo-liberal policy also led to the influx of multinational giant companies such as Monsanto which has aggressively promoted Genetically-Modified seeds, exerting considerable control over the cost, quality and availability of agricultural inputs (CHRGJ 2011: 2). However, GM seeds often fail to bring about higher yields as they require much higher amount of water and most small holder farmers lack access to proper irrigation. Furthermore, many farmers have not been properly informed that GM seeds require more water to thrive, as the warning is written in English and few farmers can read it (CHRGJ 2011: 6-8).

Worst of all, as GM seeds can not be replanted and due to Monsanto's monopoly, the option to purchase traditional non-GM seeds does not exist in some states, leaving farmers no choice but to purchase the much more expensive GM seeds annually (CHRGJ 2011: 7).

In brief, certain commercial activities of big seed companies serve as an important contributing factor to the widespread rural distress in India (Gruère 2008), as the majority of farmer suicides have occurred in modernized cash crop producing states, affecting cotton farmers in particular. As a result, the once famous cotton production belt area such as Vidarbha has turned into a notorious 'suicide belt'[4].

The suicides of farmers often lead to serious ripple effect, as surviving family members inherit the debt and widows and unmarried daughters may themselves commit suicide out of sheer desperation; in some cases, children drop out of school to become farmhands (CHRGJ 2011: 9). As a result, the destitute rural population become even more reliant on farming and

[4] *See* http://www.combat-monsanto.co.uk/spip.php?article549

harder to get rid of the trap of poverty[5].

2. Government Intervention, Market-based Mechanism and Civil Society Approaches

The rate of suicides among Indian farmers has been sustained on an unabated high level for the past two decades, calling for solid actions to rectify this precarious situation and to end this unnecessary tragedy; the second part of the paper is devoted to examining how the state, market and civil society respond to the farmers' plight respectively.

First of all, the Indian government ought to play a paramount role in combating this crisis, as agricultural expert Vijay Jawandhia states that "farmers cannot fight two enemies, he climate and unpredictable markets, without help from government."[6] To properly assess the causes and impacts of widespread rural farmer suicides, the national government set up a dedicated group to deal with farm distress in 2006 known as the Vasantrao Naik Sheti Swavlamban Mission[7], and there have been government interventions at both the national and the state level, mainly in the form of debt waiver and compensation programs to bail out affected farmers.

However, these schemes have not been very effective due to notable inadequacies in both policy design and implementation. For example, two major compensation programs initiated by the National government, the Prime Minister's Relief Funda(2006) and the Agricultural Debt Waiver and Debt Relief Scheme(2008), applied to farmers' loans from banks only and consequently, those farmers who took out loans from private moneylenders

[5] A poverty trap is "any self-reinforcing mechanism which causes poverty to persist". (http://en.wikipedia.org/wiki/Poverty_trap)

[6] Jaideep Hardikar. "DEVELOPMENT-INDIA: Two Villages, Two Very Different Stories" *Inter Press Service.* March 21, 2008.

[7] *See* http://vnss-mission.gov.in/

were excluded from such relief program; meanwhile, the basis for selection of beneficiaries is not well-defined in many cases, and women as well as lower-caste farmers often are not eligible to receive government's assistance because they do not have title to land and consequently are not legally recognized as farmers (CHRGJ 2011: 11-12).

Moreover, massive corruption and anomalies in implementation of government relief packages have been voiced by civil society[8], and the biggest impediment to solving the problem might not be at the policy level, but at the implementation level as aid from the national government may not reach farmers but be misappropriated by state government officials[9], and in many cases, compensation given to surviving families is simply funneled back to creditors and farmers (CHRGJ 2011: 11).

Most importantly, compensation schemes can only serve as short-term relief. In order to fully revitalize the agriculture sector, Indian government must improve rural irrigation infrastructure, increase access to affordable rural credit, and enforce laws to regulate agribusiness firms (CHRGJ 2011: 12, 21-23). Furthermore, in order to to help farmers adapt to modern technology, gather necessary market information and make informed decision accordingly, the Indian government should also endeavor to build proper Agricultural Knowledge and Information System(AKIS) which can serve as a vehicle for sharing ideas and principles with the various stakeholders seeking solutions for rural poverty and for making farmers partners instead of simply recipients in the process (FAO 2000). Besides, the government should also formulate policies to encourage environmentally friendly way of

[8] Kavita Kanan Chandra. "Vidarbha Jan Andolan Samiti's fight for farmers' rights". *The Weekend Leader.* 12 Jun 2013. (http://www.theweekendleader.com/Crusade/447/Vidarbha%E2%80%99s-hope.html).

[9] P. Thangaraj. "Agriculture: Need for a Complete Revamp". The Hindu. January 17, 2010. (http://www.thehindu.com/opinion/open-page/agriculture-need-for-a-complete-revamp/article81430.ece)

agricultural production such as organic farming, and minimum support price can also be set to protect farmers' benefits if necessary (see OECD 2007).

In addition to government's actions, the problem can also be solved through market-based mechanisms. Firstly, since indebtedness is the direct cause of farmers' suicide, banks could increase rural credit. It is equally important to develop comprehensive insurance safety net for farmers to properly manage internal risks in agricultural sector. Besides, seed supply should be diversified to allow farmers more purchase options, and the problem can be equally mitigated by creating more non-agricultural employment in rural areas through establishing food processing industry (OECD 2005). In addition, agricultural business enterprises ought to pay attention to their corporate social responsibility, refrain from deceptive advertising practices and address adverse impacts stemming from their commercial activities (CHRGJ 2011: 2). Furthermore, some private actors also can make their unique contributions to combating rural distress, for example a consulting firm named the GreenEarth Development produced valuable social watch report on the implementation of the Prime Minister's and the Maharashtra state government's relief packages for reducing farmer suicides in the Vidarbha region of Maharashtra in 2007, reflecting on the real impacts and inadequacies of government's interventions (GreenEarth 2007).

Compared with the state and market, civil society has played a remarkable role in remedying this acute crisis. First of all, media, scholars and some NGOs have all helped to publicize this issue and put the Indian agrarian crisis in the spotlight. Secondly, certain international institutions, including various U.N. human rights bodies, have urged the Indian government to take firm action and live up to its human rights obligations (CHRGJ 2011:

14-21). Thirdly, a number of international NGOs have widespread operations to help farmers in India, among which Actionaid stands out as a good example. Actionaid is a U.K. based anti-poverty NGO that has began its operation in India since 1972. Now with its 12 regional offices, Actionaid supports more than 90 long-term and over 350 short-term projects in India[10]. Actionaid strives to reach the most excluded communities and remote areas and is rooted in communities in order to build on alternatives emanating from people's own experiences. In addition, as a well-known international organization, Actionaid can serve as a bridge between local beneficiary and the elite policy makers. For example, in 2012 Actionaid organized two national consultation on agrarian crisis and farmer's suicides and hence brought people's representatives, civil society, farmers' organizations, academicians and policy analysts to deliberate on various critical issues[11], hence combining top-down decision making and bottle-up involvement.

Among Indian local NGOs, innovative approaches to helping farmers have been taken by the Chetna Organic program which is devoted to promoting organic farming among small holder farmers[12]. In fact, many ill effects of modern agriculture has given rise to organic farming movement that is regarded as a way to make farming both sustainable and profitable and thus has been praised as a panacea to multiple rural distress. Chetna Organic started its pilot programs in 2004 and has been expanding rapidly, representing 15,279 farmers in 2012 and aiming to include 30,000 farmers in 2015[13].

Chetna Organic aims to develop good practices that can be emulated by large scale

[10] http://www.actionaid.org/india
[11] http://www.actionaid.org/india/latest-events/stories/national-consultation-agrarian-crisis-and-farmers-suicides-india
[12] http://www.chetnaorganic.org.in/about-us
[13] http://www.chetnaorganic.org.in/about-us/achievements

government programs. It also aims to influence policies at macro level. Besides, Chetna Organic strives to become a resource organization, a knowledge repository and provides consultancy services for other development agencies.

Chetnan Organic has two national level organizations. The Chetna Organic Farmers Association (COFA) was registered in 2007 as a not for profit organization, and Chetna Organic Agriculture Producer Company Ltd (COAPCL), a complete farmer owned trading company established in 2009, is the marketing arm of the Chetna Organic program and allows farmers to establish direct relationships with brands and retailers without middlemen. Under these two national level organizations, farmers participated in Chetna Organic program are organized into Self Help Groups(SHGs) which are furthermore federated into district level cooperatives[14].

Chetna Organic has established partnership with state, market and civil society to operate various programs. For example, the Integrated Watershed Management Program (IWMP) is financed by the government of India, managed by the Department of Rural Development, Government of Andhra Pradesh and Chetna has been chosen to implement the program[15]. As another example, the Convergence of Agriculture Initiatives in Maharashtra (CAIM) program was initiated by the state government and received funding from IFAD, a specialized agency of the United Nations, and the Sir Ratan Tata Trust (SRTT), one of the oldest philanthropic institutions in India. Chetna has been provisionally selected as project implementation agency[16].

[14] http://www.chetnaorganic.org.in/about-us/organisational-structure
[15] http://www.chetnaorganic.org.in/programs/integrated-watershed-management-program-iwmp
[16] http://www.chetnaorganic.org.in/programs/convergence-agriculture-initiatives-maharashtra-caim

Chetna Organic also has a number of CSR partners. For example, Jackpot, Denmark's leading producer of organic, sustainable fashion apparel, partnered with Chetna in 2008 to ensure socially responsible chain of production by donating to Chetna Organic program to establish common infrastructure in rural areas[17]. Jackpot's cooperation with Chetna focuses on women and children's issues.

Another example is the Indo-German Watershed Development Program (IGWDP) endorsed by KFW banking group. Due to successful implementation of this program, Chetna was recognized as "The Best Project Implementation Agency" and received NR.100,000 cash prize by National Bank for Agriculture and Rural Development (NABARD) in 2011[18].

Navdanya[19], an Indian NGO founded by the famous agricultural scientist and environmental activist Dr. Vandana Shiva, is another influential Indian NGO campaigning for farmers' benefits. Navdanya is a network of seed keepers and organic producers spread across 17 states in India and aims to conserve biodiversity, rejuvenate indigenous knowledge, and empower local farmers and women. Navdanya has set up 111 community seed banks and trained over 5,00,000 farmers in sustainable agriculture. It also campaigns for seed sovereignty in opposition to monopolistic seed companies (such as Monsanto) and endeavors to expose various harms of GM seed.

In fact, protecting biodiversity has been an essential concern of national food security for both India and China. A Chinese seed program, Participatory Plant Breeding(PPB) program is a good example of conserving biodiversity through encouraging local farmers'

[17] http://www.chetnaorganic.org.in/programs/jackpot-community-development-program
[18] http://www.chetnaorganic.org.in/programs/indo-german-watershed-development-project
[19] http://www.navdanya.org/

participation. The program was initiated in 2000 by the Centre for Chinese Agricultural Policy(CCAP) and received technological as well as policy support from the Chinese Academy of Agricultural Science(CAAS). At the provincial level, the Guangxi Maize Research Institute(GMRI) was responsible for breeding hybrid maize, and at the local level, 6 farmer villages in Guangxi were selected for test and evaluation of proposed hybrid seeds. After the initiation of the program in 2000, the institute breeders started hybrid breeding and eventually selected 15 experimental hybrid seeds. Then in 2001, local farmers were invited to evaluate and select their most preferred three kinds of seeds for planting. Finally, after growing the seeds and observing their performance, farmers identified their top preference seed, which were later officially registered and released in 2003 (Li 2012: 51-56).

So in the Guangxi PPB model, farmers were involved in both the on-station selection and on-farm testing process, thus contributing to the effectiveness of this program. Nevertheless, policy designers often neglect the very subjects of their programs, as in the case of Indian farmer suicide, this tragedy is closely related to inadequacies of public policy, as Kishor Tiwari, president of the farmers' rights group 'VJAS', stated that "The target beneficiaries are never asked what they want before a relief package in planned."[20]

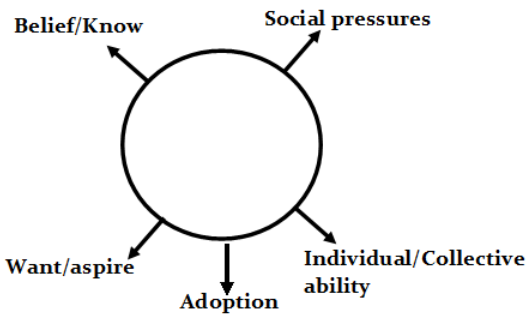
To discuss government policy, James C. Scott's influential book *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* is worth mentioning here. In the book, the author asks that why some grand policy schemes, such as the Great Leap Forward in China and collectivization in Russia, failed so tremendously, and then argues that centrally managed social plans often disregard the values, desires, and objections

[20] Kavita Kanan Chandra. "Vidarbha Jan Andolan Samiti's fight for farmers' rights". *The Weekend Leader.* 12 Jun 2013. (http://www.theweekendleader.com/Crusade/447/Vidarbha%E2%80%99s-hope.html).

of the subjects (Scott 1999). Thus when the state uses authoritarian power to effect large-scale interventions, civil society can not be prostrate but instead must effectively resist some grandiose administrative plans. So some NGO such as Actionaid adopts what is called 'strategic engagement with the state'[21], a political stance indicating that 'cooperate where you can, resist where you must'. In addition, in order to succeed, policy makers must recognize the importance of local, practical knowledge as well as farmers' reason for action. Nevertheless, one major challenge in program design is for policy makers to understand the agronomic, cultural and socio-economic drivers of farmers' needs (Li 2012: 60-61).

In this respect, this farmer's reason for action model can help us to understand why farmers engage in certain practices(Figure 1). Farmers are influenced by their own perception and motivated by their economic and social aspirations. In addition, farmers' practices are shaped by what they are able to do individually or collectively, and farmers are pressured by rewards and sanctions defined by their own social environment.

Figure 1. 'reason for action' model



Source: Jingsong Li(2012). Inducing multi-level institutional change through participatory plant breeding

[21] http://www.actionaid.org/india/who-we-are/our-approach

in southwest China.

Furthermore, farmers' organizations, such as South Indian Coordination Committee of Farmers' Movements(SICCFM)[22] and Vidarbha Jan Andolan Samiti (VJAS)/Vidarbha People's Protest Forum[23], serve different purposes and are another important component of Indian civil society movements.

3. State-Market-Civil Society Cooperation: Integrated Approaches for Multi-dimensional Crisis

Since Indian farmer suicide crisis is a multi-dimensional issue, integrated approaches need to be found to properly address it. This part will analyse State-Market-Civil Society Cooperation through the good practice of microfinance via the Self Help Groups(SHGs)-Bank Linkage Program.

This program has been launched by National Bank for Agriculture and Rural Development(NABARD). Founded in 1982 by the Indian Parliament, NABARD is the government-owned apex refinance institution and the premier agency to provide credit in rural areas[24].

In the 1980s, NABARD launched a research and determined that lack of affordable rural credit was a prominent factor leading to various rural distress, because there were mutual inconvenience and discomfort felt both by the formal banking system and the rural poor population. The poor often saw banks as 'inaccessible' and then resorted to private moneylenders who often charged usurious rates. Similarly, Banks believed that banking with

[22] http://siccfm.blogspot.com/
[23] http://andolan.blogspot.com/
[24] http://en.wikipedia.org/wiki/National_Bank_for_Agriculture_and_Rural_Development

the very poor was not viable. In addition, financial aids from the the government often put resources in the hands of the poor people without teaching them how to utilize such resources effectively (Puhazhendi 2002).

As the Chinese saying goes "teaching one to fish is better than giving one fish"[25], one solution to this predicament is the practice of microfinance that delivers financial services to the rural poor population with a strong emphasis on social and economic empowerment and participation of community (NABARD 2010). Microfinance sector has been booming in India in recent years, and the Self-Help Group (SHG) model is the dominant form of microfinance in India. In fact, SHGs have grown explosively in recent years and serve as an intermediating tool between informal rural saving groups and the main-stream banking system. A SHG usually comprises 10-20 people from homogeneous backgrounds, and most of them women[26].

SHGs function in a democratic manner and use collective wisdom to make important decisions. The members hold meetings and save certain amount of money regularly. When their savings reach a certain level, small interest loans will be made to the members. The process helps the members to learn essential financial skills such as account keeping and prioritization of needs. Most significantly, this process gradually builds financial discipline and credit history for the members. Once a SHG begins to show mature financial behavior, it can be linked to banks which will then make loans to the SHG. The bank loans are given without any collateral and at market interest rates. In this way, this program reduces bank's transaction costs because SHGs aggregate many small savings into one single deposit

[25] “授人以鱼不如授人以渔”.

[26] http://en.wikipedia.org/wiki/Self-help_group_(finance)

(Puhazhendi 2002).

SHGs can be promoted by Self-Help Promoting Institutions (SHPIs) including government, NGOs or banks, and there are three models of bank-linked SHGs (Table 1), among which the first model is the most popular. Promotion agencies will grade the SHGs before recommending them for bank loans. In this model, social capital replaces physical capital and peer pressure substitutes for collateral to ensure timely repayments.

Table 1. Three models of SHG-bank linkage program

Type of Support	Model 1	Model 2	Model 3
Promotion	NGO or government agency promotes SHGs	NGO or government agency promotes SHGs	Bank promotes SHGs
Financing	Bank lends directly to SHGs	NGO or government agency obtains funds from banks and lends to SHGs	Bank lends directly to the group

Source: The Consultative Group to Assist the Poor. "Sustainability of Self-help Groups in India: Two Analyses." 2005.

Obviously, different roles and responsibilities of the state, market and civil society can be observed in this model. First of all, NABARD, representing the government, has made considerable efforts to facilitate this program by providing refinance funding for banks at a below-market interest rate and by granting support to partner agencies for promoting SHGs. In addition, NABARD provides training for banks and other stakeholders, and it endeavors to

encourage micro-enterprise through SHGs.

Secondly, NGOs help promoting SHGs and provide necessary financial training (such as account keeping) to the members, and promoting NGOs also need to grade the SHGs before recommending them for bank loans. Furthermore, SHGs can also serve as instruments for other development plans that a particular NGO might have, as evidenced in the case of the Chetna Organic that uses SHGs to organize its farmer members. Thirdly, the banks expand their own business coverage by promoting and providing credit for SHGs.

The SHGs-Bank Linkage program has created remarkably positive social impacts by increasing employment rates among members and improving their confidence and self-esteem. As a result, many female members have received better treatment from their family members. Furthermore, this program has also helped to build decision-making and communication capacities for members. Consequently, some behavior changes have also been observed. For example, members generally have become more assertive towards ill social behavior such as drinking, gambling and family violence. In addition, as members must come out to join group meetings regularly, the mobility of SHG group members has also been improved (Puhazhendi 2002).

However, despite these remarkable achievements, SHG model is an ongoing discussion and some problems still remain, such as how to enhance the effectiveness and transparency of different SHGs, and whether these groups really have included the poorest marginal population. Another issue is how to realize the social potential of SHGs to facilitate other development plans (EDA 2006).

4. Dragon V.S. Elephant: a Brief Comparison between India and China in

Agriculture and Rural Development

In May 2013, Chinese premier Li Keqiang met Manmohan Singh in New Delhi during his first foreign trip since taking office, a strong political signal that China wishes to establish comprehensive strategic cooperative relationship with its great neighbor. As two emerging Asian giants, both China and India have sustained rapid growth in terms of annual GDP growth. Some expert even estimates that by 2030, China and India together could account for as much as 1/3 of the world economy (Dobson 2011: 3). Obviously the emergency and development of India and China is likely to exert remarkable influence on the global political and economic picture.

A number of similarities can be readily found between India and China as both countries have traditionally been agrarian economies and more than half of their population still depend on agriculture for livelihood[27]. Both India and China have undergone market reforms, and during the process of modernization, both countries have witnessed massive rural-urban migration and increasing income and regional disparities. Besides, China and India are faced by similar social welfare and environmental protection issues.

On the other hand, China outperforms India in terms of average annual income per capita as the GNI per capita of China is about 4 times that of India in 2010[28], and the world bank rates China is as an upper middle income country and India lower middle income country[29]. In addition, there are significant differences in social, cultural and political institutions and practices between India and China. For example, India was once under the

[27] 69.1% of Indian and 50.8% of Chinese population lived in rural areas in 2010 according to recent data provided by the world bank.

[28] The respective data for India and China in 2011 is $1,420 and $4,940. http://data.worldbank.org/indicator/NY.GNP.ATLS.CD

[29] http://data.worldbank.org/country/china; http://data.worldbank.org/country/india

dominance of the Great Britain for about 200 years while China, after achieving its Independence, underwent 30 years' planned economies. As a result, the basis for subsequent economic growth for India and China is different, Moreover, due to different historical and cultural factors and considering path dependence[30], the economic growth patterns for India and China also differ from each other. For example, China's economic miracle is primarily fuelled by its booming manufacture sector and China is the market leader in hardware manufacture industry whereas India is famous for its IT service and software sector (OECD 2010).

Furthermore, as a good development path should built on good governance, economic growth and social cohesion for both India and China (OECD 2005b), and in terms of governance, Indian democracy was a parliamentary system at the federal and state levels, but with bureaucratic governance at the lower levels, striving towards democratic decentralization (Narayana 2006). In comparison, Chinese society is undergoing a crucial transformation with rapid growth of the market and civil society, nevertheless the single party regime in China has put constraints on freedom of expression. One the other hand, because the Chinese authority puts a lot of emphasis on investment in public infrastructure, China has much better infrastructure than India in general.

In terms of rural development, agriculture in both India and China is still primarily subsistence farming characterized by abundant labor and small-scale production with limited mechanization (OECD 2007; OECD 2005), and both countries aim to integrate small holder

[30] Path dependence explains how the set of decisions one faces for any given circumstance is limited by the decisions one has made in the past, even though past circumstances may no longer be relevant.
(http://en.wikipedia.org/wiki/Path_dependence)

farmers into the larger market. Like India, China is faced by many challenges in rural development, such as food security, lack of proper rural credit, the "left-behind" children and the degradation, soil erosion as well as water pollution.

However, China's land tenure system is based on land lease contracts and farmland is de facto owned by the collectives, so through equal distribution of land use rights, China avoided having large numbers of rural landless workers vulnerable to famine or other economic shocks (OECD 2005a). In comparison, a large number of women as well as lower-caste farmers in rural India are still landless, constituting the majority of the destitute population in India.

As a result, while alleviation of poverty and malnutrition remains an essential aspect of policy making in India (OECD 2007), the 'Three Rural Issues' ('peasantry, rural areas and agriculture') are a major concern for the Chinese government. Improving rural income and welfare and mitigating agricultural pollution have been the main policy objectives for China.

5. Conclusion

This paper addresses causes and consequences of the alarming farmer suicide crisis in India and explores government interventions, market-based mechanism and civil society movements in combating this enormous tragedy, hence demonstrating that State-Market-Civil Society cooperation is pivotal to alleviating Indian farmers' plight, to empowering marginal rural population and to ultimately revitalizing Indian agriculture sector. The conclusion part will summarize various comparative advantages and disadvantages of state, market and civil society as shown by this case.

First of all, the state uses laws, policies and regulations to enforce social changes, so the

state can implement standardized development programs on a large scale and is usually more reliable. However, the political elites are usually distant from the local beneficiaries and as a result, some development schemes may be flawed as evidenced in the limited success of Indian government compensation schemes to bail out farmers. And government is usually slow to react due to hierarchy and complicated administrative procedures as the Indian government has long been criticized for its inaction to deal with farmer suicide crisis. In addition, the government's motivation to combat complicated social issues is also relatively low.

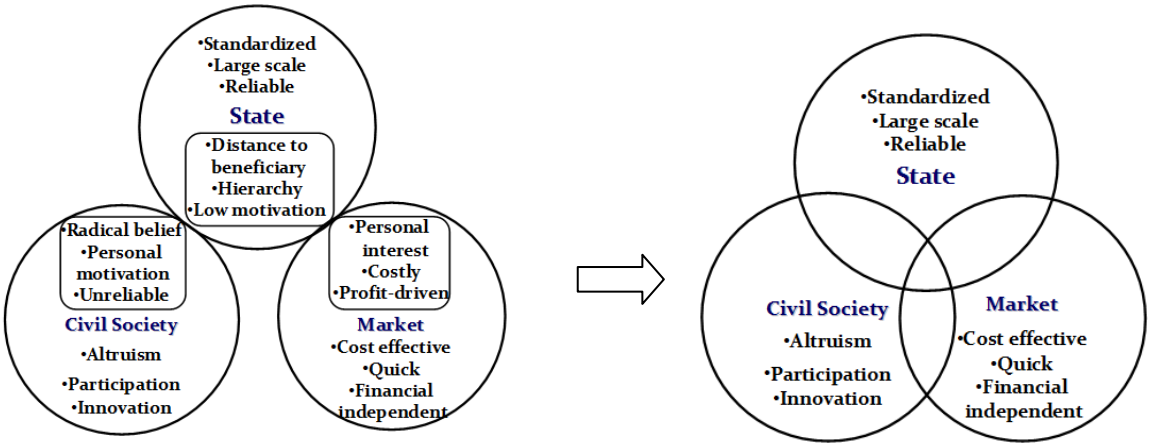
In contrast, market approach is often cost-effective and quick, and commercial organizations can usually achieve financial independence for sustainable operation as shown by the success of the farmer-owned company in the Chetna Organic program. Nevertheless, market also has its drawbacks in dealing with social issues. Most significantly, market is profit-driven and can be selfish. For example, the monopoly and deceptive marketing of some multi-national seed companies have proven to be devastating to many small holder farmers in India. As another example, in the case of the self-help group programs discussed before, banks are usually the least enthusiastic in promoting self-help groups.

In this respect, civil society movements are driven by altruism and and are often rooted in communities, so civil society can represent marginal rural population and call for the authority to take action. In addition, civil society can also pioneer in addressing social problems through innovation as shown in the case of Chetna Organic. However, civil society also has its own weaknesses. For example, some NGOs may be unreliable, and others may have radical attitudes as some NGOs and activists in India advocate revamping the entire

Indian agricultural system and returning to traditional way of farming.

On balance, state, market and civil society are complementary to each other both in structure and function, thus under ideal conditions of comprehensive cooperation, the weaknesses of the state, market and civil society might be mitigated and their advantages maximized, and then synergy will follow (Figure 2).

Figure 2. Synergy of State-Market-Civil Society Cooperation



6. Questions for Further Discussion

1. Farming-centric V.S. Farmer-centric policies: Rapid economic growth, if not paralleled by social support policies, can be neither inclusive nor sustainable and often occurs at the expense of environment. So how can policy makers achieve a balance between rural economic growth and social welfare of farmers? How to make agriculture both profitable and sustainable?

2. Tradition V.S. Modernization: The ever increasing commodification of agricultural produce has outstripped the traditional self-sufficient mode of agricultural production. However, with the erosion of biodiversity and indigenous knowledge, a series of social and

environmental problems have emerged in the process, then how to effectively preserve local traditional knowledge for the sake of sustainable agricultural production?

3. Downward Empowerment: What should state, market and civil society do to facilitate participatory governance? In policies design processes, how to integrate traditional and indigenous knowledge with scientific research and theories?

4. What can India and China learn from each other in terms of economic development, social welfare and environmental protection?

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Sustainable Green Project Risk Management Model for Metro Rail Transit System Project

Dr. Debasis Sarkar

Abstract— Sustainable green transportation systems are the need of the hour for sustainable development. Such systems provide environment and user friendly modes of fast commutation to urban population. But construction and operation of such infrastructure projects of the present era are subject to huge risks and uncertainties throughout all the phases of the project, thus reducing the probability of successful completion of the project within stipulated time and cost frame. Thus, sustainable green project risk management model where an effective risk response plan and sustainable mitigation measure framework based on knowledge and past experience is formulated prior to the occurrence of the risks would be a pragmatic solution. This paper aims at developing a green sustainable project risk management model for underground corridor construction for metro rail which is a part of Mass Rapid Transit System for urban infrastructure. Project risk management primarily comprises of cost and schedule uncertainties and risks. These risks can be assessed or measured in terms of likelihood, impact and consequences. The method of measurement of project risk is based on Expected Value Method (EVM). A case study of underground metro corridor construction in the city of an emerging economic nation of South Asia has been considered for this research work. The methodology for this work is questionnaire based survey responded by the experts associated and involved in this project and with similar type of projects in metro rail. Based on this study it was found that project cost-overrun and time-overrun can be 22.5 % and 23.4 % respectively. Decision Tree analysis was adopted to decide about the adoption of suitable risk mitigation measures. Monte Carlo simulation has been applied to make the proposed model more realistic.

Keywords- Sustainable; Green; Project Risk Management; MRTS; Underground corridor; Metro rail

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Dr. Debasis Sarkar is Associate Professor & Head with Dept. of Civil Engineering, Pandit Deendayal Petroleum University, India
(+91079 23275426, debasis.sarkar@sot.pdpu.ac.in)

I. INTRODUCTION

For an emerging economy transportation enables functioning of urban areas efficiently by providing access and mobility. Passenger transport has an overriding influence on the functioning of the city. With growth, the mobility needs increases. People's personal choices and freedom get expressed in increased ownership and use of personalized vehicles. The public agencies operating public transport systems often fail to restructure service types to meet with the changing demand pattern. Thus there is a need to develop an efficient user and environment friendly public transit system to support the rapidly growing demand of the city. Underground corridor Metro Rail Transit System (MRTS) is a project of such kind which has the potentiality of meeting the needs of an urban city of an emerging economy. But construction of such infrastructure transportation project involves several risks and uncertainties throughout the entire phases of the project starting from feasibility to execution and operation Reilly and Brown [5]. This paper aims at developing a Project Risk Management model for an underground corridor of MRTS project. According to Roetzhiem [6] and Nicholas [4] project risks primarily comprises of schedule uncertainties and cost uncertainties. These risks would result in huge time and cost overrun which would ultimately reduce the probability of successful completion of the project within stipulated time and cost frame. Risk management can be carried out effectively by following the basic steps like risk identification, risk assessment, risk response planning and mitigation measures. For effective risk assessment, proper investigation and identification of the sources of risks need to be carried out by the risk management team. These risks can be assessed or measured in terms of likelihood, impact and consequences. The most appropriate way of dealing with the project risk is treating it as a function of likelihood and impact [Risk = f (likelihood, impact)] [4] and [7]. Finally, as risk is a component which cannot be eliminated, suitable risk mitigation measures are to be suggested which will enable to reduce the identified project risks [2], [3].

II. CASE STUDY

The project considered for analysis is construction of an underground corridor for metro rail operations in a metro city of an emerging economic nation in South Asia. The scope of work is design and construction of an underground metro corridor with six underground stations and a twin tunnel system. The underground stations are referred to as ST_1, ST_2,…. ST_6. Here ST_6 is the terminal station equipped with an over-run tunnel. The client is a public sector company floated jointly by the State and Central Government. The principal contractor is a Joint Venture (JV) of three foreign contractors and two domestic contractors. Type of contract is Design Build Turnkey (DBT) where the principal contractor is required to design the underground corridor and execute it. The contract period is about five years (exclusively for execution). The feasibility phase of the project is an additional five years. The project cost for execution is about INR 18 billion. The activity chart of the sample stretch under analysis consisting of the cut and cover tunnel (CT_5) connecting two stations ST_5 and ST_6, ST_6 station box and the over-run tunnel (CT_6) succeeding ST_6 station box is provided in Table 1A and 1B.

III. CASE ANALYSIS

Some basic assumptions are considered during the analysis. These assumptions are (i) the maximum cost overrun permissible is 25 % of the basic cost beyond which the project becomes less feasible and (ii) the maximum permissible time overrun for infrastructure projects is about 30% to 50%.

The risks identified under each activity have been listed and a detailed questionnaire consisting of all the identified risks as per the classification stated above have been framed. The detailed questionnaire consisting all of the identified risks as per the classification was circulated amongst about 80 experts having adequate experience in underground construction projects or similar infrastructure projects. These experts were required to respond about the likelihood of occurrence and the weightage associated with each risk as per their experience. The methodology for receiving the filled up questionnaire from the respondents were personal approach, telephonic conversation, e-mails and posts. The experts were Designers, Consultants, Dy. project leader, Project managers, Dy. project managers, CEOs, Managing directors, Area managers, Quality assurance / Quality control incharges, Safety incharges, Senior engineers and Project engineers of the principal contractor of the above project, client organization, consulting organization, major sub-contractors of the above project and other ongoing metro rail projects within the country. Of

about 80 experts 50 had responded to this study and the mean of all the responses of respective risk likelihoods and their associated weightages in the related activities have been considered. The inconsistent responses were revised by conducting a second round questionnaire survey using Delphi technique. Common risk sources are presented in Table 2.

A. Application of EVM for Risk Analysis of the Project

The network diagrams consisting of the major activities of the project have been drawn and their activity times (early start, early finish, late start and late finish) have been calculated by forward and backward pass and then their critical path was tracked out. The duration along the critical path is the longest duration path and is considered as the duration of the project. The BCE and BTE of each activity and sub-activity of the project have been calculated as per the actual site data. The corrective cost and time for each activity have been assumed as a certain percentage (25 % to 75 %) of BCE and BTE respectively depending upon the severity and casualty caused by that risk. Each activity of the project as presented in figure 1 have been analyzed at sub-activity level for computation of RC, RT, EC, ET and risk severity. The detailed analysis for computation of risk cost and time for all the activities of the project is presented in Table 3.

Thus as per the analysis, *EC* of the project is *22.51 % higher than the BCE* of the project. The *ET* of the project is 23.36 *% higher than the BTE*. As per the basic assumptions considered for risk management analysis the cost overrun should not exceed 25 % of the estimated base cost and the time overrun should not be more than 30-50 % of the estimated base time. Exceeding these limits would increase chances of the project becoming less feasible. The risk management analysis predicts that the expected cost of the project is 22.51 % higher than the estimated base cost. This situation is highly alarming as it is the upper limit of the permissible cost overrun. It requires meticulous planning and proper risk mitigation measures to enhance the probability of success of the project. The expected time predicted from the analysis is 23.36 % higher than the estimated base time which is nearing the upper limit of permissible time overrun. Thus it is essential to judiciously follow the risk mitigation measures to ensure that the project is completed within scheduled time frame.

B. Application of Monte Carlo Simulation

Monte Carlo simulation has been applied to predict the outcome of the expected time (ET) and expected cost (EC) of all possible paths of activities as represented in the network diagram of the project (Figure 1). Monte Carlo simulation also takes into account the effects of near critical paths becoming critical. By carrying out detailed path analysis of the project network diagram, it is observed that path A-C-E-D-G-I-P-T has the longest duration of 3786 days and hence the critical path (refer Figure 1). The corresponding cost for completion of activities along this path is INR 1220 Million. It is also observed that the probability of successful completion of the project within stipulated time and cost frame is only 4% (0.625 x 0.730 x 0.738 x 0.681 x 0.720 x 0.623 x 0.616 x 0.602 = 0.040). Path A-B-D-G-I-P-T is a near critical path with the probability of about 4.8% for successful completion within stipulated time and cost frame. There are all chances of this path becoming critical.

TABLE 1A: MAJOR ACTIVITIES IN MRTS PROJECT (ST_6, CT_5,CT_6)

Activity	Description	Immediate Predecessors	Duration (Days)	ES	EF	LS	LF
A	Feasibility studies	-	1875	0	1875	0	1875
B	Design	A	295	1875	2170	1985	2280
C	Technology selection	A	90	1875	1965	1875	1965
D	Traffic diversion	B,E	475	2280	2755	2280	2755
E	Utility diversion	C	315	1965	2280	1965	2280
F	Survey works	B,E	290	2280	2570	2821	3111
G	Soldier / King piles	D	356	2755	3111	2755	3111
H	Timber lagging	C	240	1965	2205	2871	3111
I	Soil excavation	G,F,H	330	3111	3411	3111	3441
J	Rock excavation	L,R	165	2655	2820	3276	3441
K	Fabrication and erection of construction decks	C	170	1965	2135	2941	3111
L	Fabrication and erection of steel struts	C	690	1965	2655	2421	3111
M	Rock anchor installation	N,O	285	2280	2565	3156	3441
N	Shotcreting & rock bolting	L,R	120	2655	2775	2871	2991
O	Subfloor drainage	Q	170	2110	2280	2821	2991
P	Water proofing	I,K,J,M	120	3441	3561	3441	3561
Q	Diaphragm wall construction	C	145	1965	2110	2604	2749
R	Top down construction	Q	122	2110	2232	2749	2871
S	Permanent structure	N,O	570	2280	2850	2991	3561
T	Mechanical / Electrical installations & services	P,S	225	3561	3786	3561	3786
U	Backfilling & restoration works	N,O	225	2280	2505	3561	3786

TABLE 1B: TIME ESTIMATES OF MRTS PROJECT

Activity	Duration (Days)	ES	EF	LS	LF
A	1875	0	1875	0	1875
B	295	1875	2170	1985	2280
C	90	1875	1965	1875	1965
D	475	2280	2755	2280	2755
E	315	1965	2280	1965	2280
F	290	2280	2570	2821	3111
G	356	2755	3111	2755	3111
H	240	1965	2205	2871	3111
I	330	3111	3411	3111	3441
J	165	2655	2820	3276	3441
K	170	1965	2135	2941	3111
L	690	1965	2655	2421	3111
M	285	2280	2565	3156	3441
N	120	2655	2775	2871	2991
O	170	2110	2280	2821	2991
P	120	3441	3561	3441	3561
Q	145	1965	2110	2604	2749
R	122	2110	2232	2749	2871
S	570	2280	2850	2991	3561
T	225	3561	3786	3561	3786
U	225	2280	2505	3561	3786

ES: Early Start; EF: Early Finish; LS: Late Start; LF: Late Finish

TABLE 2**:** COMMON RISK SOURCES OF MRTS PROJECT

S No.	Risk Source Description
1	Risks due to delay in approval of detailed project report (DPR)
2	Land acquisition risks
3	Design risks
4	Technology selection risks
5	Approval and permit risks
6	Joint venture risks
7	Financial and investment risks
8	Political risks
9	Environment related risks
10	Geo technical risks
11	Major / minor accidents during execution
12	Unforseen heavy rain
13	Force Majeure risks like flood, fire earthquake etc.
14	Labour agitation and strikes
15	Inflation risks
16	Risks due to delayed payment from client
17	Risks due to delayed payment to subcontractor

TABLE 3: PROJECT EXPECTED COST AND TIME ANALYSIS OF MRTS PROJECT

Base Cost Estimate (INR Milion)	Risk Cost (INR Million)	Base Time Estimate (Days)	Risk Time (Days)	Expected Cost (INR Million)	Expected Time (Days)
3240	729.2	3786	884.47	3969.2	4670.47

TABLE 4**:** OUTCOME OF PATH ANALYSIS OF MRTS PROJECT NETWORK DIAGRAM AFTER APPLYING MONTE CARLO SIMULATION

Path	Activity / Path	Path duration (days)	Cost (INR Million)	Probability of Success
1	A-B-D-G-I-P-T	3676.17	1192.8	4.8%
2	A-C-E-D-G-I-P-T	3785.98	1222.8	4%
3	A-C-E-F-I-P-T	3244.88	961.7	6.6%
4	A-C-H-I-P-T	2879.88	871.1	8.2%
5	A-C-K-P-T	2479.67	820.9	10.6%
6	A-C-L-J-P-T	3164.79	1081.9	6.5%
7	A-C-Q-R-J-P-T	2741.60	922	5.7%
8	A-C-Q-O-S-T	3074.89	1501	11.2%
9	A-C-Q-O-U	2504.95	650.7	15.4%

From the above analysis we observed that path 2 (A-C-E-D-G-I-P-T) has the longest duration of 3785.98 days and remains to be critical. The corresponding cost for completion of all the activities along the critical path is INR 1222.8 Million. The probability of successful completion of path 2 or critical path within scheduled time is 50%. The probability of successful completion of the near critical path or path 1 within scheduled time is 84.13% (Z = 1.009, P = 0.8413). Also the probability of successful completion of all the paths with the scheduled time is 42.05% (P = 0.8413 x 0.5 x 1 x 1 x 1 x 1 x 1 x 1 x 1 = 0.4205)

Carrying out about 15,000 runs of Monte Carlo simulation, the EC was found to have a value of INR 3533.5 Million and the ET of the project was found to be 4352.22 days.

IV. CONCLUSIONS

In present research work it has been found that the numbers of major and minor risks involved during the underground corridor construction of the MRTS project from the feasibility to completion of the execution, are large and if not treated or mitigated properly, the probability of successful completion of the project within stipulated time and cost frame will reduce. This will have a direct impact on the efficiency and profitability of the organization.

As per the analysis carried out by EVM based on the expert questionnaire survey the expected project cost for the sample stretch under analysis (530 m tunnel from station ST5 to ST6, ST6 station box and 180 m over-run tunnel) is about 22.51 % higher than the base cost estimate of the project. According to basic assumption made for the analytical procedure adopted, the maximum permissible cost over-run for the project is 25 % , thus if proper project risk management is not carried out by the authority, the project will result in cost over-run and time over-run which will ultimately reduce the feasibility of successful completion of the project. The expected project time as obtained by the analysis is about 23.36 % higher than the base time estimate of the project, the maximum permissible time over-run as per basic assumptions being 30 – 50 % of the base time, this figure is also highly alarming making the concerned authority feel that the need for carrying out proper risk management for such type of complex infrastructure projects. Carrying out about 15,000 runs of Monte Carlo simulation, the EC was found to have a value of INR 3533.5 Million and the ET of the project was found to be 4352.22 days.

Hence considering the results of all the analyses carried out in this research work, it can be concluded that for complex infrastructure projects like that of an underground corridor construction, about INR 0.82 Million per day per station would be incurred extra if proper risk management is not followed to mitigate the anticipated risks. Thus for six underground stations for this 6.6 km underground metro corridor package approximately INR 4.92 Million per day have to incurred extra by the project authorities. The difference in EMV between option 4 and 5 being only INR 15.9 Million, it is recommended that the project authorities should go for option 5 and adopt all mitigation measures and follow entire Risk Management Model. A major limitation of the model adopted for analysis is that the entire model being probabilistic the outcome of the analysis is largely dependent on opinion of the likelihood and weightages of the identified risks obtained from expert questionnaire survey. Also any sort of misinformation provided will result in erroneous results. Though at present, a very nominal percentage of identified risks can be insured under the existing "Contractors All Risk Policy" but potentiality of insurance and means of making insurance as a strong risk mitigation tool for construction industry will be a future scope of research.

Generalized risk management model for underground corridor MRTS project is proposed on the basis of the detailed analysis carried out. This model can be effectively implemented in the ongoing and upcoming metro rail projects across the nation.

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Dr. Debasis Sarkar has graduated in Civil Engineering from Bangalore University, India in 1996, M. Tech in Building Science & Construction Management from Indian Institute of Technology, Delhi in 2001 and Ph.D in Project Management from DD University, India 2009.

He is presently Associate Professor and Head at Dept. of Civil Engineering, Infrastructure Engineering & Management Programme, School of Technology, Pandit Deendayal Petroleum University, Gandhinagar, Gujarat, India. He has about seven years of industrial and about eleven years of academic experience. He was also employed as senior engineer and site incharge with Delhi metro rail project. His research interest includes project management, risk management, advanced construction technologies and green building technologies.

Dr. Sarkar is life member of Institute of Engineers India and annual member of Indian Roads Congress. He is also the editorial board member of a number of peer reviewed international journals.

The Analysis of Soil Retention Function and its Value Evaluation in Typical Ecological Function Area in Beijing

Authors: **Tian Mei-rong, Gao Ji-xi***

Nanjing Institute of Environmental Science, Ministry of Environmental Protection, Nanjing 210042,China.

(* Corresponding author: gaojx168@163.com)

Abstract:

Mentougou district was considered to be a typical ecological function area in Beijing, the soil conservation ability of the ecosystems in the area was studied and the ecological value was evaluated based on the Landsat TM7. The results showed that the ecosystems of Mentougou area supplied important ecological service function in soil conservation and the total soil conservation amount added up to 2.27×10^7/a and the total value was 3.12×10^8yuan, in which the value for preventing water corrosion was 4.43×10^6 yuan whilst the value for preventing wind corrosion was 3.07×10^8 yuan.

Key word: Soil conservation, Ecological value, Universal Soil Loss Equation

Background

Soil conservation, which is one of the most important components in maintaining ecological function, is considered to be an essential part of territorial management too. A great deal of research [1-6] had been done towards the soil conservation and the quantitative calculation, which mainly adopted the Universal Soil Loss Equation (USLE) and modifications to estimate the soil conservation quantity based on the calculation of soil erosion in the study area.

As one of the 16 districts/counties in Beijing, capital city of China, the Mentougou district, lies in the upper hand direction of Beijing with abundant biological, geological, climate and cultural resources bred by its diverse geomorphic types and microclimate, which serves as the ecological barrier for the environmental and climate vulnerable capital and is considered to be an important construction area for ecological conservation. However, the quantitative research on the ecological service function of Mentougou district is insufficient, which influences the estimation of its ecological service contribution to the whole capital city. Based on the calculation of soil conservation function and economical value, which was the important part of total value of ecological service function of Mentougou district, our study aimed at promoting the full understanding of the ecological service value of the district and improving scientific ecological protection measures and ecological reimbursement mechanism, thus supplying scientific basis for the ecological and environmental protection in Mentougou district.

1. Study area

Mentougou district is located in the west of Beijing with an area of about 1,455 square kilometers, which lies within E115°25′00″-E116°10′07″and N 39°48′34″- N40°10′37″. Mentougou is mountainous in terrain. In fact, the mountainous terrain—including a hundred or more peaks—occupy 98.5% of the entire area, and the plain area only covers 1.5%. Mentougou belongs to the mid-latitude continental monsoon climate, and the annual average wind speed is 2.7m/s. Affected by middle latitude atmospheric circulation and monsoon, the annual precipitation varies dramatically year by year with an average amount of 563.4 mm, the highest precipitation 970.1 mm appeared in 1977 and the lowest 369.1mm appeared in 2004. The soil in Mentougou mainly belongs to regional cinnamon soil, while the mountainous leaching cinnamon soil mainly covers the area under the altitude 900m and brown soil covers the area with the altitude between 900-1900m, there is also dotted distribution of mountain meadow soil with the elevation of altitude.

2. Methodology

2.1 Data source

Based on RS/GIS technology, our study adopted the data from the 1:250,000 remote sensing picture of the Mentougou district, including the topographic slope and the land type data as the basis of the calculation. We used ArcGis、Erdas to divide the district into 25m×25m grid, which was used as the basic unit to calculate the soil conservation.

2.2 Calculation method of soil conservation

The four main types of land including forest, shrubbery, open forest and meadow covered 89% of the total area, therefore we only calculated the soil conservation of the four types.

2.2.1 Calculation method of water erosion

The USLE was adopted to calculate the quantities of actual and potential soil erosion caused by water, the discrepancies between which would be considered as the soil conservation. The potential soil erosion indicated the quantity of erosion in the absence of vegetation cover and conservation measures, while the actual erosion considered the two factors.

$$\text{USLE: } A_r = R \times K \times L_S \times C \times P \quad (1)$$

$$A_p = R \times K \times L_S \quad (2)$$

Soil Conservation: $Ac = Ap - Ar$ (3)

In which, Ar is actual soil erosion per unit,t/($hm^2 \cdot a$)； Ap is potential soil erosion per unit;,t/($hm^2 \cdot a$) ； Ac is soil conservation per unit,t/($hm^2 \cdot a$) ； R is rainfall erosion factor,MJ·mm/($hm^2 \cdot h \cdot a$)； K is soil erodibility factor ； LS is slope length and steepness factor；C is surface vegetation cover factor； P is soil conservation measure factor. (While the surface vegetation cover and soil conservation measure were not considered in the USLE, which meant C=1, P=1, then Ap = R×K×LS).

2.2.1.1 Estimation of R

The rainfall erosion factor R is used to measure the erosion ability of specific rainfall. Y.Xiao[7] etc. had developed the linear relation between R and $P_{5\text{-}10}$ (the total amount of rainfall between May and October): $R=0.0355\ P_{5\text{-}10}+0.6576$ based on the data collected from 13 meteorological station in Tibet Plateau, W.Wang etc. calculated the rainfall and R in their study, in which the R of Beijing-327.0 was also adopted in this study.

2.2.1.2 Estimation of K and C

Based on the investigation of the land types in Mentougou district, the brown soil covers 77% of the total area and the values of K are 0.012 and 0.124 [8]for common brown soil and leachate brown soil respectively.

The surface vegetation cover factor C reflects the effect of different vegetation, which is closely related to land use type and coverage density. According to the available literature, the values of factor C[9] of different vegetation types were shown below.

Table.1 Value of K and C factors of different vegetation types

Vegetation type	Soil type	K	C
Forest	Leachate brown soil	0.124	0.06
Shrubbery	Leachate brown soil	0.124	0.04
Open forest	Brown soil	0.012	0.22
High coverage meadow	Brown soil	0.012	0.043
Middle coverage meadow	Brown soil	0.012	0.15
Low coverage meadow	Brown soil	0.012	0.24

2.2.1.3 Calculation of LS

Based on the formula developed by Y. Huang[10], the Spatial distribution characteristics could be acquired. The slope grade was distracted from the digital elevation map, and the slope length was then calculated by the ratio of the grid size and the slope grade.

$$Ls = (l/22)^{0.3}(\theta/5.16)^{1.3} \quad (4)$$

2.2.1.4 Estimation of P

Since there was no water and soil conservation measure in the forest and meadow of Mentougou district, the P was considered to be equal to 1.00.

2.2.2 The calculation method of wind erosion

The driving factors of wind erosion were very complicated, therefore, no generally accepted models had been developed so far. In our study, we adopted the wind erosion model developed by Z. Dong[11],which considered the wind erosion flux is the function of wind speed, relative air humidity, average soil particle size, soil hardness, vegetation coverage and slope grade, and the wind erosion could be calculated by integrate the flux with the time and space.

$$Q = \int_t \int_x \int_y \left\{3.9\left(1.0413 + 0.00441\theta + 0.0021\theta^2 - 0.0001\theta^3\right)\left[V^2\left(8.2\times10^{-5}\right)^{VCR}/\left(H^8 d^2 F\right)x,y,t\right]\right\} d_x d_y d_t \quad (5)$$

In which, Q is the quantity of wind erosion, t; v is wind speed, m/s; H is relative air humidity, %; VCR is vegetation coverage ratio, %; d is average soil particle radius, mm; F is soil hardness, N/cm^2; θ is slope grade， x、 y is distance, Km； t is time, s.

Similar with the water erosion, the calculation of wind erosion is as follows ：

$$Q_c = Q_w - Q_n \quad (6)$$

In which：Q_c is soil conservation, t；Q_w is the soil erosion without the vegetation coverage, t；Q_n is actual soil erosion, t.

2.2.2.1 The value of V, H, d and F factors

The calculation of wind erosion mainly considered the sand immobilization function of the ecosystem, so we adopted the 15m/s, which was the average speed of strong wind; the average humidity H was 66%[12]; the average soil particle radius was 0.99mm; the soil hardness was $0.51N/cm^2$ in average base on relevant literatures.[13]

2.2.2.2 The calculation of radian

In order to carry out integration，it was necessary to transfer the slope grade into radian, the following formula was applied：

$$\text{Radian} = \theta * 3.14/180° \quad (7)$$

2.2.2.3 Vegetation coverage

We processed the RS image by the ARCGIS software, and the 1:250,000 image of vegetation coverage (25m×25m grid) was then acquired.

2.3 Evaluation of soil conservation of ecosystem

The surface vegetation is considered to contribute to the soil conservation in terms of protecting land resources, preventing soil erosion, maintain soil fertility, preventing retention and deposit of the sediment. Three kinds of method were used to calculate the value of soil conservation including ① potential soil erosion method ② alternative engineering method and ③ comprehensive

cost-effectiveness method. In our study, the potential soil erosion method was adopted.

2.3.1 Reducing the land loss

$$Ed = \mathrm{Qi} \bullet \mathrm{P}/(10^4 \rho \bullet h) \tag{8}$$

In which：Ed is the value for reducing the land loss, yuan；Qi is the value of soil conservation, t；P is the opportunity cost per unit, yuan/t； ρ is soil bulk density, t/m^3； h is the thickness of the soil layer, m.

According to statistics, the average thickness of the soil plough layer was 30 cm, the average soil bulk density for forest land and meadow is 1.10 t/m^3. The loss of soil would lead to the loss of productivity, therefore, we used the 5480.5 yuan/ha, which was the highest land price then, as the land price.

2.3.2 Maintaining soil fertility

$$\mathrm{En}=\mathrm{E1}+\mathrm{E2} \tag{9}$$

$$E_1 = \mathrm{Qi}\sum_{i=1}^{n} \bullet P1i \bullet P2i \bullet P3i \tag{10}$$

$$\mathrm{E2}=\mathrm{Qi}\cdot\mathrm{P} \tag{11}$$

In which：En is the value of maintaining soil fertility, yuan；E1 is the value of maintaining Nitrogen (N), Phosphorus (P), and Kalim (K), yuan；E2 is the value of maintaining organics, yuan；Qi is soil conservation，t/a；P1i is the concentration of N, P and K in the soil，%；P2i is the ratio of transforming into pure N, P and K into fertilizer (132/14, 132/31, 75/39 respectively)%；P3i is the retail price of the fertilizer, yuan；P is the value of organics, yuan/t.

According to statistics, the average content of organics in the surface soil layer in Mentougou district was 3%, the average contents of total N, P, and K were 0.19%, 0.02% and 0.08% respectively. The ratio of firewood transformed into soil organics was 2:1 while the opportunity cost of firewood was 51.3 yuan/t; the retail price of diammonium phosphate (NH_4) and kalium chloratum (KCl) were 2928yuan/t and 1935 yuan/t.

The calculation of the value for maintaining N, P, and K was to convert the pure N, P, and K into NH_4 and KCl.

2.3.3 Reducing deposit of the sediment

According to the regularity of sediment motion in main watershed of China, 24% of the sediment originated from soil loss would deposited in the rivers, lakes or reservoirs, therefore we used the water storage cost to calculate the value of reducing deposit of the sediment

$$Ea = 0.24Qsc * C / \rho \tag{12}$$

In which：Ea is the value for reducing retention of the sediment, yuan/a；Qsc total quantity of soil conservation, t；C is the engineering cost for reservoirs, yuan/m^3； ρ is the bulk density of the

sediment, 1.27 t/ m^3， the capacity cost per unit is 5.714 yuan/m^3。

2.3.4 Reducing retention of sediment

The value for reducing retention the sediment could be calculated based on the cost of excavating the sediment and the quantity of the sediment deposition reduced in the forest.

$$Es = 0.24Qsc * c / \rho \tag{13}$$

In which：Es is the value for reducing retention the sediment, yuan/a；Qsc is the total quantity of soil conservation, t； C is the cost for excavating the sediment, 15yuan/m^3； ρ is the bulk density of the sediment, 1.27 t/ m^3.

2.3.5 Reducing wind erosion

$$V = Qn \bullet S / \rho \tag{14}$$

In which, V is the value for reducing wind erosion, yuan； Qn is the quantity of the immobilized sand,t；S is the cost for excavating the sand, 15yuan/m^3； ρ is the bulk density of the sand, 1.10 t/ m^3, the cost for excavating sand is 15 yuan / m^3.

3. Results

3.1 Spatical analysis of soil conservation

3.1.1 Soil conservation for water erosion

According to the calculation method of water erosion, the value and capability of soil conservation of different ecosystems in Mentougou district were shown below.

Table. 2 The value and capability of soil conservation of different ecosystems in Mentougou district

Unit：(t/a)

Categories	Forest	Shrubbery	Open forest	High-density meadow	Middle-density meadow	Low-density meadow	Total
Actual erosion	7143	4589	538	57	228	95	12650
Potential erosion	89125	68132	1743	1511	1140	268	161919
Soil conservation	81982	63543	1205	1454	912	173	149269
Conservation capability	12.48	14.85	3.24	26.51	5	2.82	

Note：Soil conservation =Potential erosion/Actual erosion

As was shown in the table above, the value and capability of soil conservation of different ecosystems in Mentougou district varied spatially, in which the forest had the highest soil conservation of 81982 t/a, the low density meadow had the lowest soil conservation of 173t/a, and the total soil conservation is 149269t/a; the highest conservation capability 26.51t/a appeared in the high-density meadow while the lowest capability was 2.81 in low density meadow.

The soil conservation function of same ecosystem also varied spatially. According to the analysis by

GIS, the grids in which the soil conservation capability were above 400 t/ (hm^2·a), 200-400 t/ (hm^2·a), 100-200 400 t/ (hm^2·a) and below 50 400 t/ (hm^2·a) covered 57.5%, 15%, 11.2% and 7.9% of the total area respectively.

Table.3 Statistics of the soil conservation capability in Mentougou district

Category	<50	50-100	100-200	200-400	>400
Ratio %	7.9	8.4	11.2	15.0	57.5

3.1.2 Soil conservation for wind erosion

Based on the wind erosion model, we calculated the values of soil erosion and conservation in different ecosystems in Mentougou district, thus concluded the erosion intensity and conservation intensity. The results showed that the low density meadow had the highest value of erosion intensity at 7.25 while the open forest had the lowest at 0.68; on contrast, the open forest had the highest conservation intensity at 211.51 and the forest had the lowest at 162.87.

Table.4 The values of soil erosion and conservation in different ecosystems in Mentougou district

Land Type	Area（hm^2）	Actual wind erosion（t/a）	Potential wind erosion（t/a）	Soil conservation（t/a）	Erosion intensity	Conservation intensity
Forest	62767.33	235251	10458551	10223300	3.75	162.87
Shrubbery	36432.34	98078	6687353	6589275	2.69	180.86
Open Forest	19657.39	13320	4171027	4157707	0.68	211.51
High density meadow	7075.25	27707	1431004	1403297	3.92	198.34
Middle density meadow	719.44	514	145451	144937	0.71	201.46
Low density meadow	133.38	1449	26783	25334	7.25	189.94
Total	-	376319	22920169	22543850	-	-

Note：Soil conservation intensity =Soil conservation/Area；Soil erosion intensity =Soil erosion/Area

3.2 Economic value of soil conservation

According to the formulas and the factors above, we calculated values of the soil conservation for wind erosion and water erosion in different ecosystems separately, as were shown below.

Table.5 Economic values of soil conservation of different ecosystems in Mentougou district

Type	Soil conservation for water erosion(t/a)	Reducing land loss(yuan)	Reducing soil fertility loss(yuan)	Reducing deposit (yuan)	Reducing retention (yuan)	Soil conservation for wind erosion (t/a)	Conservation value for wind erosion (yuan)
Forest	81982	136152	1975061	88525	232389	10223300	139408636
Shrubbery	63543	105529	1530839	68614	180121	6589275	89853750
Open Forest	1205	2001	29030	1301	3415	4157707	56696004
High density meadow	1454	2414	35028	1570	4121	1403297	19135868
Middle density meadow	912	1514	21971	984	2585	144937	1976413
Low density meadow	173	287	4167	186	490	25334	345463
Total	149269	247899	3596099	161182	423124	22543850	307416136

Based on the calculation, we concluded that the total value of soil conservation was 3.12×10^8 yuan, in which the values for water erosion and wind erosion were 4.43×10^6yuan and 3.07×10^8yuan, which indicated that the ecosystem of Mentougou districts was playing an far more important role on For the soil conservation value for water erosion, reducing soil fertility loss, retention, land loss and deposit contributed to 80%, 10%, 6% and 4% separately, which indicated that the most important function was to contribute to prevent the loss of soil fertility.

4. Discussion

The ecosystem mainly contributed to the soil conservation in terms of preventing water erosion, preventing wind erosion as well as cultivating land and soil. Due to the time consuming process of cultivating land and soil, it is difficult to evaluate quantitatively in this aspect, thus, we mainly discussed the soil conservation function of the vegetation and the evaluation of preventing water and wind erosion.

Regarding the wind erosion model, plenty of research had been done by scholars all over the world, however the wind erosion was affected by different factors including wind speed, humidity, slope grade and vegetation, which were correlated with each other, therefore, no general accepted model had been developed yet. In our study, we adopted the model developed by Z.Dong, which was based on a small watershed whose climate conditions were similar to our study area. However, it had to be pointed out that due to specific differences in detailed climate, soil conditions, there were discrepancies in choosing the factors of the model, which may lead to deviated results in the calculation. We will separate the study area into different function sub-area according to the types of erosion in order to pursue more accurate estimation in the next step research.

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The assessment of the heavy metal enrichment of the soils around Kapan town, Armenia

G. A. Gevorgyan[1,3], K. A. Ghazaryan[1], H. S. Movsesyan[1], N. P. Ghazaryan[2], K. V. Grigoryan[1]

[1]Department of Ecology and Nature Protection of the Faculty of Biology of the Yerevan State University, Alex Manoogian st. 1, 0025, Yerevan, Armenia
[2]State Committee of Science of the Ministry of Education and Science of the Republic of Armenia, Orbeli st. 22, 0028, Yerevan, Armenia
[3]Institute of Hydroecology and Ichthyology of the Scientific Center of Zoology and Hydroecology of NAS RA, Paruyr Sevak st. 7, 0014, Yerevan, Armenia
E-mail: gev_gor@mail.ru

Abstract

The concentrations of Cr, Mn, Ni, Cu, Zn, As, Mo, Cd and Pb in the soils around the Kapan copper-molybdenum combine and the tailings storage facility of Geghanush were determined, and the degree of the heavy metal pollution of the soils was assessed. The soil samples were taken from the control site and the 12 riskiest sites around the combine and the tailings storage facility in 2013. Investigations showed that heavy metal concentrations in the soils were conditioned by both lithogenic and anthropogenic sources, but the content of copper in all investigated sites were mostly conditioned by anthropogenic factor especially metallurgical industrial activity. According to the enrichment factor values, the soils were moderately and significantly enriched with copper. The second anthropogenic metal was molybdenum. According to the geo-accumulation index values, the investigated soils were: moderately to strongly polluted with copper; unpolluted to strongly polluted with molybdenum; unpolluted to moderately polluted with manganese, nickel, chromium, zinc, arsenic, cadmium and lead. Thus, the activity of the Kapan copper-molybdenum combine caused the heavy metal pollution of the surrounding soils, and it isn't recommended the inhabitants of the territory to use these soils for agricultural purposes without the implementation of recultivation works.

Key words: Armenia, Kapan town, metallurgical industrial activity, soil, heavy metals, pollution

Introduction

Heavy metal contamination in soil is a major concern because of their toxicity and threat to human life and the environment. Toxic heavy metals entering an ecosystem may lead to geo-accumulation, bio-accumulation and bio-magnifications [3].

The metal content in soil is a sum of metals originating from natural processes and human activities. It is estimated that the contribution of metals from anthropogenic sources in soil is higher than the contribution from natural ones. Significant increases in soil metal content are found in areas of high industrial activity where accumulation may be several times higher than the average content in non-contaminated areas. Additionally, areas distant from industrial centres also show increased metal concentrations due to long-range atmospheric transport [7].

The accumulation of heavy metals can degrade soil quality, reduce crop yield and the quality of agricultural products and affects ecosystems, the health of human, animals negatively. Hence, the assessment of metal contamination is of vital importance in agricultural areas [4].

Heavy metal pollution of surface soils due to intense industrialization and urbanization has become a serious concern in many developing countries. Kapan town is located in the south of the Republic of Armenia where mining and metallurgical industries are highly developed. Due to metallurgical industrial activities, the soils in this territory have been endangered by heavy metal pollution.

The aim of the present study was to determine the degree of the heavy metal pollution of the soils around Kapan town and to estimate the impact of metallurgical industrial activity on the soils.

Material and methods

The soils of the 2 riskiest areas around Kapan town were analyzed (Fig. 1):

1. around the Kapan copper-molybdenum combine (samples №№ 01-06);
2. around the tailings storage facility of Geghanush (samples №№ 07-12).

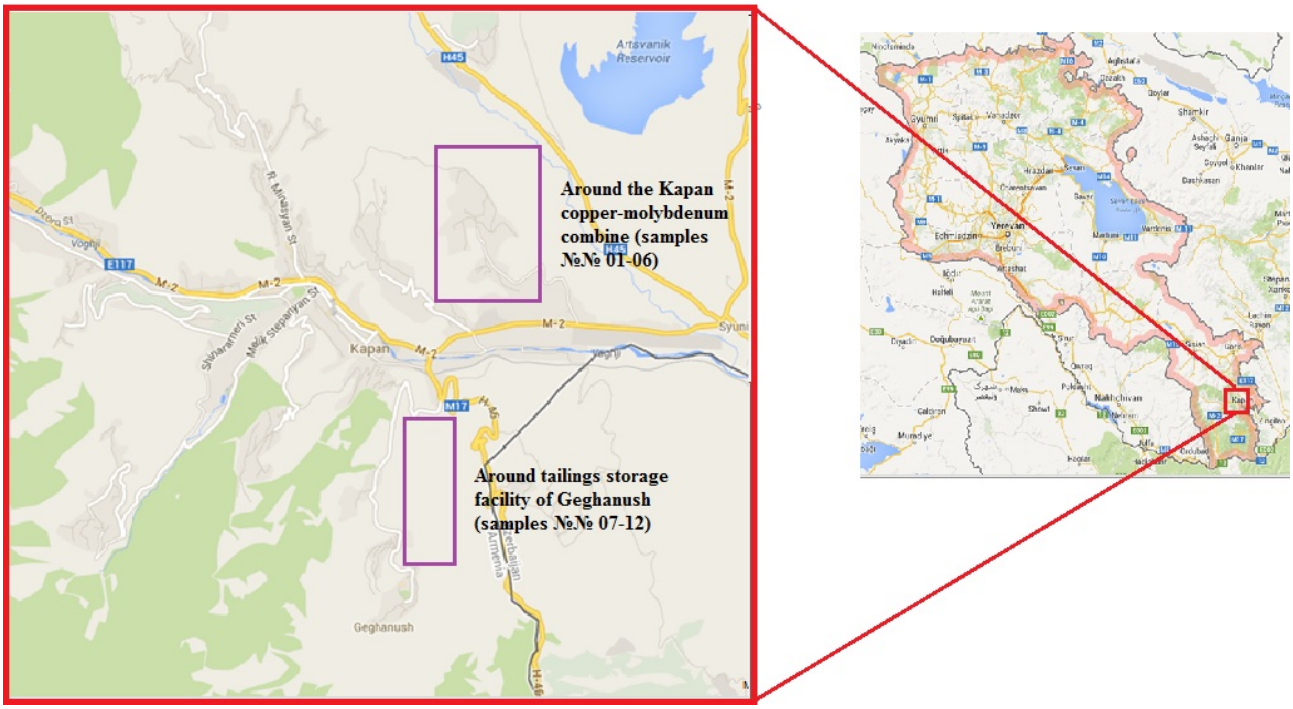


Figure 1. The map of Armenia showing the investigated territories around Kapan town.

The 12 sections in the horizon A of the soils (0-22 cm) were made in the selected sites in 2013. The control section was made in the site which was 4 km away from the Kapan copper-molybdenum combine. The sections were made manually.

The soil sampling was carried out by the standard method, well-known in soil science. All labware and sampling apparatus were pre-soaked in 5% nitric acid solution followed by distilled water for a day prior to sampling for removing the trace concentrations of metals.

The samples of the soils were taken from a depth of 0-20 cm at 5 m intervals on a grid measuring 20 m x 20 m and with the center point of the grid at the sample location. After the homogenization and removal of unwanted content (stones, plant material, etc.), the samples were air-dried at room temperature, sieved to pass a 1 mm mesh and stored in an all-glass jar for the analysis of heavy metals.

The content of heavy metals such as Cr, Mn, Ni, Cu, Zn, As, Mo, Cd and Pb was determined by the mass spectrometric method using "ELAN 9000" inductively coupled plasma mass spectrometer (ICP-MS).

The proportion of anthropogenic metal was determined for each metal by the following formula:

$$\text{Anthropogenic metal} = (X - X_c)/X \times 100 \qquad (1),$$

where X is metal concentration in the soil samples, X_c is metal concentration in the control sample.

Enrichment factor (EF) calculation is a common approach to estimate anthropogenic impact on soils. EF is calculated as follows [1, 3, 4, 7]:

$$EF = [(Mc/Mr)]s / [(Mc/Mr)]b \qquad (2),$$

where *Mc* is the content of examined element, *Mr* is the content of reference element, *s* is the sample, and *b* is the background. A reference element is often used as a conservative element. The most common reference elements are Zn, Mn, Al, Fe, etc. [1-3, 6, 7]. In this study, Zn was used as a reference element as it mainly originated from natural lithogenic sources.

Five contamination categories are recognized on the basis of the enrichment factor which are presented in Table 1 [1, 3, 6, 7].

Table 1. Contamination categories according to the enrichment factor values.

EF value	Contamination categories
< 2	deficiency to minimal enrichment
2-5	moderate enrichment
5-20	significant enrichment
20-40	very high enrichment
> 40	extremely high enrichment

Geo-accumulation index (Igeo) was used to assess the degree of the heavy metal pollution of the soils. The index is calculated as:

$$Igeo = \log_2 Cn /1.5Bn \qquad (3),$$

where Cn is the concentration of the element in the samples, Bn is the background value of the element, and the factor 1.5 is used to take into account the possible lithological variability [1, 3, 5, 7].

The degree of heavy metal pollution is assessed in terms of seven contamination classes based on the increasing numerical value of the index which is presented in Table 2 [3].

Table 2. The classification of the soil contamination degree according to the geo-accumulation index values.

Igeo value	Contamination categories
< 0	unpolluted
0 – <1	moderately polluted
1 – <2	moderately to strongly polluted
2 – <3	strongly polluted
4 – < 5	strongly to very strongly polluted
≥ 5	very strongly polluted

Results and discussion

The concentrations (mg/g) of some heavy metals in the soils around Kapan town are presented in Table 3.

Table 3. The content (mg/g) of some heavy metals in the soils around Kapan town.

Sample number	Cr	Mn	Ni	Cu	Zn	As	Mo	Cd	Pb
1	0.09945	1.55761	0.11852	0.06736	0.12713	0.01653	0.00114	0.00045	0.01682
2	0.07391	1.24473	0.09055	0.04430	0.08651	0.01021	0.00050	0.00026	0.01220
3	0.05747	1.01725	0.07293	0.04414	0.08434	0.01039	0.00050	0.00027	0.01064
4	0.04316	0.93946	0.05885	0.03257	0.06598	0.00686	0.00025	0.00025	0.00874
5	0.02332	0.81323	0.03683	0.07276	0.09030	0.00911	0.00055	0.00023	0.00402
6	0.01754	1.16219	0.02640	0.04611	0.12667	0.02249	0.00093	0.00052	0.02243
7	0.04743	1.44788	0.04595	0.06093	0.08443	0.00611	0.00032	0.00016	0.00544
8	0.04714	1.50461	0.05231	0.05538	0.09767	0.00717	0.00053	0.00023	0.00713
9	0.01857	1.61149	0.02052	0.08674	0.08645	0.00274	0.00034	0.00014	0.00348
10	0.03114	1.58789	0.02663	0.10042	0.06304	0.00403	0.00012	0.00019	0.00264
11	0.02768	0.85438	0.03259	0.03784	0.05615	0.00344	0.00028	0.00012	0.00295
12	0.04374	1.18599	0.05605	0.05868	0.08286	0.00777	0.00040	0.00021	0.00697
Control	0.04320	0.52770	0.02640	0.00897	0.07550	0.00748	0.00018	0.00024	0.01026

Considering the heavy metal content of the control (background) sample as representing lithogenic metal, the proportion of anthropogenic metal was determined which is presented in Table 4. Investigations showed that heavy metal concentrations in the soils were conditioned by both lithogenic and anthropogenic sources, but the content of copper in all investigated sites were mostly conditioned by anthropogenic factor especially metallurgical industrial activity. The second anthropogenic metal was molybdenum (Tab. 4). According to the enrichment factor values, the soils were (Tabs 1, 5):

- deficiency to minimal enriched with chromium, arsenic, cadmium and lead;
- deficiency to minimal and moderately enriched with manganese, nickel and molybdenum;
- moderately and significantly enriched with copper.

Table 4. The proportion (%) of anthropogenic metal in the soils around Kapan town.

Sample number	Cr	Mn	Ni	Cu	Zn	As	Mo	Cd	Pb
1	57	66	78	87	41	55	84	47	39
2	42	58	71	80	13	27	64	8	16
3	25	47	64	80	10	28	64	11	1
4	0	44	55	72	0	0	28	4	0
5	0	35	28	87	16	18	67	0	0
6	0	55	0	81	40	67	81	54	54
7	9	64	43	85	11	0	44	0	0
8	8	65	50	84	23	0	66	0	0
9	0	67	0	90	13	0	47	0	0
10	0	67	1	91	0	0	0	0	0
11	0	38	19	76	0	0	36	0	0
12	1	56	53	85	9	4	55	0	0

Table 5. The enrichment factor values in the soils around Kapan town.

Sample number	Cr	Mn	Ni	Cu	As	Mo	Cd	Pb
1	1.4	1.8	2.7	4.5	1.3	3.8	1.1	1.0
2	1.5	2.1	3	4.3	1.2	2.4	0.9	1.0
3	1.2	1.7	2.5	4.4	1.2	2.5	1.0	0.9
4	1.1	2.1	2.6	4.2	1.0	1.6	1.2	1.0
5	0.5	1.3	1.2	6.8	1.0	2.6	0.8	0.3
6	0.2	1.3	0.6	3.1	1.8	3.1	1.3	1.3
7	1.0	2.5	1.6	6.1	0.7	1.6	0.6	0.5
8	0.8	2.2	1.5	4.8	0.7	2.3	0.7	0.5
9	0.4	2.7	0.7	8.4	0.3	1.6	0.5	0.3
10	0.9	3.6	1.2	13.4	0.6	0.8	0.9	0.3
11	0.9	2.2	1.7	5.7	0.6	2.1	0.7	0.4
12	0.9	2.1	1.9	6.0	0.9	2.0	0.8	0.1

For assessing the impact of the metallurgical industrial activity on the soils around Kapan town, the degree of the heavy metal pollution of the soils was assessed by the geo-accumulation index (Igeo). According to the Igeo values, the investigated soils were (Tabs 2, 6):

- unpolluted to moderately polluted with chromium, manganese, nickel, zinc, arsenic, cadmium and lead;
- moderately to strongly polluted with copper;
- unpolluted to strongly polluted with molybdenum.

Table 6. The degree of the heavy metal pollution of the soils around Kapan town according to the geo-accumulation index values.

Sample number	Cr	Mn	Ni	Cu	Zn	As	Mo	Cd	Pb
1	0.6	1.0	1.6	2.3	0.2	0.6	2.1	0.3	0.1
2	0.2	0.7	1.2	1.7	-0.4	-0.1	0.9	-0.5	-0.3
3	-0.2	0.4	0.9	1.7	-0.4	-0.1	0.9	-0.4	-0.5
4	-0.6	0.2	0.6	1.3	-0.8	-0.7	-0.1	-0.5	-0.8
5	-1.5	0.04	-0.1	2.4	-0.3	-0.3	1.0	-0.6	-1.9
6	-1.9	0.6	-0.6	1.8	0.2	1.0	1.8	0.9	0.5
7	-0.5	0.9	0.2	2.2	-0.4	-0.9	0.2	-1.2	-1.5
8	-0.5	0.9	0.4	2.0	-0.2	-0.6	1.0	-0.6	-1.1
9	-1.8	1.0	-0.9	2.7	-0.4	-2.0	0.3	-1.4	-2.1
10	-1.1	1.0	-0.6	2.9	-0.8	-1.5	-1.2	-0.9	-2.5
11	-1.2	0.1	-0.3	1.5	-1.0	-1.7	0.1	-1.6	-2.4
12	-0.6	0.6	0.5	2.1	-0.5	-0.5	0.6	-0.8	-1.1

Conclusions

The activity of the Kapan copper-molybdenum combine caused the heavy metal pollution of the surrounding soils. The soils were highly polluted especially with copper which was conditioned by the high content of this metal in ores.

It isn't recommended the inhabitants of the territory to use these soils for agricultural purposes without the implementation of recultivation works.

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The investigation of the biocenose in the Karchaghbyur river biotope affected by the small hydropower plant

G. A. Gevorgyan

Institute of Hydroecology and Ichthyology of the Scientific Center of Zoology and Hydroecology of NAS RA, Paruyr Sevak st. 7, 0014, Yerevan, Armenia
E-mail: gev_gor@mail.ru

Abstract

Hydrological, hydrophysical and hydrobiological studies were implemented in the Karchaghbyur river in October-December 2013.

Hydrological studies showed that the Karchaghbyur river velocity decreased according to the observation sites situated before and after the small hydropower (SHP) plant which was conditioned by water intake needed for the SHP. The river water temperature increased according to the observation sites situated before and after the SHP because the water is reserved before the intake by the SHP causing an increase in the water temperature.

The higher values of the quantitative and qualitative parameters of zooplankton in the Karchaghbyur river were registered in the site situated after the SHP as this site of the river had lower velocity, and there were the thickets of higher plants. These conditions are favorable for the growth of zooplanktonic organisms. According to the observation sites situated before and after the SHP, the quantitative and qualitative parameters of phytoplankton decreased which is explained by the pressure of zooplanktonic organisms as well as a change in thermal regime as diatomic algae, which were a dominant group, grow well in low temperature conditions. In the observation site situated after the SHP, where the representatives of the family Gammaridae prevailed quantitatively, the quantity and biomass of benthic macroinvertebrates were higher than the quantitative parameters in the site situated before the SHP which was conditioned by the existence of the thickets of macrophytes that are preferable feed and habitat for the representatives of the family Gammaridae. The qualitative parameters of benthic macroinvertebrates decreased according to the observation sites situated before and after the SHP which may have been conditioned by a decrease in dissolved oxygen level in the conditions of the comparatively low river flow, high water temperature and an increase in the content of the organic matters of artificial origin.

Key words: Armenia, Karchaghbyur river, river velocity, thermal regime, biocenose, small hydropower plant

Introduction

Today, energy consumed all over the world comprises 34.5% liquids, 26% coal, 23.5% natural gas, 5.5% nuclear and 10.5% renewable [30]. The increasing demand of energy in many countries, especially in developing countries has led to the acceleration of energetic sphere development rate. In recent years, the number of small hydropower plants has increased drastically and has a tendency to increase for producing ecologically clean energy in energetic sphere [22, 31]. Being a renewable energy source, the latters' application in energetic sphere has a high economic importance. Giving priority to the development of this economic sphere, the possible impact of small hydropower plants on aquatic ecosystems is ignored or little attention is paid. Water intake needed for small hydropower plants decreasing the natural flow of rivers affects their hydrological, physicochemical and hydrobiological parameters [14, 28]. Water natural flow reduction and thermal regime change in a riverbed lead to the formation of a new biotope and a new biocenosis, the quantitative and qualitative properties of which are significantly different from previous biocenosis.

A similar situation is also observed in the Lake Sevan basin where the rivers are influenced by the small hydropower plants located on them. The Karchaghbyur river, a tributary of Lake Sevan, is situated in the eastern part of Armenia.

The aim of the present study was to investigate the biocenose in the Karchaghbyur river affected by the small hydropower plant.

Material and methods

The object of the study was the Karchaghbyur river. Hydrological (river velocity), hydrophysical (water temperature) and hydrobiological (phytoplankton, zooplankton and macrozoobenthos) studies were implemented in October-December 2013. Monthly observations, measurements and samplings were done in the sites situated before and after the small hydropower plant located on the river.

Water temperature was measured by a water thermometer.

For the calculation of the river velocity in the investigation sites, the length of the investigation sites of the river was measured. A bobber was vented from the selected point of the river, and a stopwatch was started. The watch was stopped after the bobber passed the selected distance. The river velocity was determined by dividing the selected distance by the time recorded on the watch.

Phytoplankton: 1 litre water sample taken from each site was fixed immediately with 40% formaldehyde solution (0.4% final concentration) and was stored in a dark place. The further processing was carried out under laboratory conditions. The fixed samples were settled in dark space for 10-12 days, and then the volume of the experimental samples was decreased from 1000ml to 100ml by a siphon (№76). Repeating the same process for the second time, the volume of the experimental samples was reduced to 10ml [20].

The qualitative and quantitative analyses of phytoplankton were done by the standard methods accepted in hydrobiology [11].

The species of planktonic algae were identified by the determinants of freshwater systems [6, 24-26, 30, 32].

Zooplankton: The samples were collected by a bucket of a volume of 5–10 litres, then the water was filtered by a plankton net (№76) and was fixed with 4% formaldehyde solution. The further processing of the samples was executed under laboratory conditions [10, 19]. The investigaton of the quantitative and qualitative parameters of zooplankton was executed by the hydrobiological standard methods [2, 3, 8, 16, 17].

Macrozoobenthos: The samples were taken from the different biotopes of benthic fauna by a device of a surface of 0.09m^2. The animals were moved in cans and were preserved with 4% formaldehyde solution. The further processing of the samples was executed under laboratory conditions. The animals were separated from the substrate and were sorted into different taxonomic groups [1, 33]. The identification of taxonomic groups and the determination of quantitative parameters were done by the standard methods accepted in hydrobiology [7, 12, 21].

Results and discussion

Hydrological studies showed that during the investigation period, the values of the velocity of the Karchaghbyur river in the observation site situated after the small hydropower plant (SHP), compared to the values of the same parameter in the observation site situated before the SHP, decreased which was conditioned by water intake needed for the SHP (Tab. 1). The river water temperature increased according to the observation sites situated before and after the SHP because the water is reserved before the intake by the SHP causing an increase in the water temperature (Tab. 1).

Table 1. The thermal regime and velocity of the Karchaghbyur river.

Observation site	Karchaghbyur river					
	October (25.10.13)		November (16.11.13)		December (07.12.13)	
	T (C°)	V (m/s)	T (C°)	V (m/s)	T (C°)	V (m/s)
Before SHP	8	0.75	6.5	0.73	2	0.69
After SHP	10	0.5	9	0.43	4.5	0.38

During the investigation period, the quantitative and qualitative parameters of zooplankton in the Karchaghbyur river site situated after the SHP were higher than in the river site situated before the SHP, because water (river velocity) and thermal regimes in the observation site situated after the SHP were more favorable for the growth of zooplanktonic organisms (Tabs 1, 2) [5, 27]. The existence of the thickets of higher plants in this observation site of the river was also favorable for the growth of zooplankton. An inverse phenomenon was observed in the phytoplankton community – the diversity loss and a reduction in the qualitative parameters according to the observation sites situated before and after the SHP which is explained by the pressure of zooplanktonic organisms as well as a change in thermal regime as diatomic algae, which were a dominant group, grow well at low temperature conditions (Tabs 1, 3) [4]. In October and November, according to the observation sites situated before and after the SHP, the portion of green-algae in phytoplankton increased which may have been conditioned by a decrease in river velocity, an increase in the temperature and the content of biogenic elements entering into the river from permanent pollution sources in the river catchment basin [4, 18].

Table 2. The species composition and quantitative parameters (N – quantity (individum/m^3), B – biomass (mg/m^3)) of zooplankton community in the Karchaghbyur river.

Taxonomic group	Karchaghbyur river											
	October (25.10.13)				November (16.11.13)				December (07.12.13)			
	Before SHP		After SHP		Before SHP		After SHP		Before SHP		After SHP	
Species	N	B	N	B	N	B	N	B	N	B	N	B
Euchlanis dilatata	42	0.08	340	6.84	42	0.1	80	0.17	30	0.05	95	0.09
E. lucksiana	63	0.126	460	0.95	42	0.1	135	0.29	-	-	-	-
Cephallodella gibba	-	-	51	0.04	-	-	43	0.03	30	0.03	-	-
Conochilus unicornis	63	0.013	-	-	42	0.01	-	-	40	0.008	-	-
Paracyclops fimbriatus	-	-	40	0.32	-	-	28	0.12	-	-	15	0.04
nauplius	-	-	51	0.11	-	-	40	0.05	-	-	32.86	0.04
Total	**168**	**0.219**	**942**	**8.26**	**126**	**0.21**	**326**	**0.66**	**100**	**0.088**	**142.86**	**0.17**

Table 3. The qualitative and quantitative composition (N – quantity (cell/l), B – biomass (g/m^3)) of phytoplankton community in the Karchaghbyur river.

Taxonomic groups	Karchaghbyur river											
	October (25.10.13)				November (16.11.13)				December (07.12.13)			
	Before SHP		After SHP		Before SHP		After SHP		Before SHP		After SHP	
Species	N	B	N	B	N	B	N	B	N	B	N	B
Cyanophyta												
Aphanothece clathrata	8000	0.01824	8000	0.01824	16000	0.02	24000	0.3	-	-	56000	0.12768
Microcystis aeruginosa	-	-	4000	0.012	8000	0.024	17000	0.05	8000	0.024	12000	0.036
Aphanizomenon f-a	-	-	12000	0.084	-	-	-	-	32000	0.224	-	-
Oscillatoria sp.	-	-	88000	0.352	-	-	30000	0.07	16000	0.04	-	-
Phormidium foveularum	28000	0.0224	-	-	-	-	-	-	120000	0.096	-	-
Phormidium sp.	52000	0.104	40000	0.2	-	-	60000	0.2	16000	0.032	-	-
Phormidium papyraceum	-	-	-	-	-	-	-	-	-	-	40000	0.032
Bacillariophyta												
Amphora	-	-	8000	0.0096	-	-	20000	0.02	28000	0.0336	-	-
Nitzschia sigmoidea	16000	0.08	-	-	-	-	-	-	4000	0.02	16000	0.08
Nitzschia hungarica	-	-	8000	0.04	-	-	16000	0.08	-	-	-	-
Nitzschia kutz.	-	-	-	-	-	-	20000	0.1	12000	0.06	8000	0.04
Nitzschia linearis	-	-	36000	0.18	40000	0.2	-	-	48000	0.24	20000	0.1
Nitzschia dissipata	-	-	-	-	40000	0.2	-	-	32000	0.16	12000	0.06
Nitzschia acicularis	44000	0.22	-	-	30000	0.1	-	-	-	-	-	-
Nitzschia subtilis	-	-	-	-	12000	0.06	-	-	12000	0.06	-	-
Nitzschia microcephala	-	-	-	-	-	-	-	-	12000	0.06	-	-
Nitzschia sp.	-	-	-	-	-	-	-	-	-	-	4000	0.02
Meridion circulare	-	-	-	-	-	-	-	-	12000	0.0024	4000	0.0008
Cocconeis placentula	8000	0.036	16000	0.072	16000	0.072	20000	0.09	-	-	20000	0.09
Fragilaria capucina	76000	0.2128	24000	0.0672	60000	0.16	24000	0.06	144000	0.4032	88000	0.2464
Fragilaria construens	32000	0.0896	328000	0.9184	100000	0.2	250000	0.7	1324000	3.7072	364000	1.0192
Tabellaria fluculosa	-	-	-	-	-	-	-	-	4000	0.02	-	-
Melosira varians	388000	1.94	-	-	-	-	-	-	56000	0.28	8000	0.04
Ceratoneis arcus	4000	0.016	-	-	-	-	-	-	96000	0.384	28000	0.112
Rhoicosheia curvata	4000	0.016	8000	0.032	-	-	-	-	-	-	8000	0.032
Pinnularia major	4000	0.04	-	-	4000	0.04	-	-	16000	0.16	-	-
Navicula hungarica	20000	0.176	-	-	-	-	-	-	4000	0.0352	-	-
Navicula distas	8000	0.016	-	-	-	-	-	-	12000	0.1056	4000	0.0352
Navicula cryptocephala	12000	0.1056	-	-	-	-	-	-	32000	0.2816	12000	0.1056
Navicula sp.	24000	0.2112	-	-	48000	0.4112	-	-	20000	0.176	-	-
Navicula pygmaea	-	-	-	-	4000	0.0352	-	-	4000	0.0352	-	-
Navicula tuscula	-	-	-	-	-	-	-	-	4000	0.0352	-	-
Pinnularia major	-	-	4000	0.04	-	-	-	-	-	-	-	-
Didymoshenia geminata	-	-	-	-	30000	0.7	-	-	20000	0.5	-	-
Stephanodiscus kutz.	-	-	4000	0.018	-	-	-	-	-	-	-	-
Synedra ulna	-	-	-	-	8000	0.0024	-	-	8000	0.0024	-	-
Synedra acus	-	-	-	-	16000	0.004	-	-	-	-	-	-
Achnanthes miutissima	4000	0.008	-	-	-	-	-	-	-	-	-	-
Tabellaria flucculosa	-	-	-	-	8000	0.04	-	-	-	-	-	-
Gomphonema olivaceum	16000	0.08	-	-	-	-	-	-	4000	0.02	-	-
Diatoma vulgare	-	-	4000	0.008	30000	0.15	-	-	12000	0.024	16000	0.032
Diatoma hiemale	-	-	-	-	-	-	-	-	12000	0.024	-	-
Cymbella helvetica	-	-	-	-	8000	0.1	-	-	4000	0.08	-	-
Cymbella ventricosa	-	-	-	-	50000	0.25	-	-	44000	0.88	32000	0.64
Cymbella sp.	-	-	-	-	-	-	-	-	-	-	4000	0.08
Didymoshenia geminata	-	-	-	-	20000	0.5	-	-	20000	0.5	-	-
Cymatopleura solea	-	-	-	-	-	-	-	-	-	-	4000	0.048
Total	**748000**	**3.39184**	**592000**	**2.05144**	**548000**	**3.2688**	**481000**	**1.67**	**2192000**	**8.7056**	**760000**	**2.97688**

In the Karchaghbyur river site situated after the SHP, where the representatives of the family Gammaridae prevailed quantitatively, the quantity and biomass of benthic macroinvertebrates were higher than the quantitative parameters in the river site situated before the SHP which was conditioned by the existence of the thickets of macrophytes that had been formed due to the low velocity and nutrient regime of the river and are preferable feed and habitat for the representatives of the family Gammaridae (Tab. 4) [9]. The qualitative parameters of macrozoobenthos decreased according to the observation sites situated before and after the SHP which may have been conditioned by a decrease in dissolved oxygen level in the conditions of the comparatively low river flow, high water temperature and an increase in the content of the organic matters of artificial origin [13, 15].

Table 4. The qualitative and quantitative composition (N – quantity (individum/m^3), B – biomass (mg/m^2)) of benthic macroinvertebrates in the Karchaghbyur river.

Taxonomic group		Karchaghbyur river											
		October (25.10.13)				November (16.11.13)				December (07.12.13)			
Order	Family	Before SHP		After SHP		Before SHP		After SHP		Before SHP		After SHP	
		N	B	N	B	N	B	N	B	N	B	N	B
Veneroida	Pisidiidae	6	35	11	70	2	11	6	31	-	-	4	18
	Limnaeidae	-	-	-	-	-	-	-	-	-	-	2	235
Gastropoda	Planorbidae	16	72	-	-	7	31	-	-	2	11	-	-
Amphipoda	Gammaridae	2	2	1298	132441	-	-	1090	111200	-	-	1035	101906
	Lumbricidae	44	1513	31	1961	30	990	19	599	28	-	11	377
Oligochaeta	Tubificidae	194	195	39	57	198	180	24	61	208	112	11	29
Arhynchobdellida	Erpobdellidae	2	22	4	165	-	-	2	39	-	-	2	40
Rhynchobdellida	Glossiphoniidae	-	-	2	22	-	-	-	-	-	-	-	-
	Caenidae	538	114	-	-	28	5	-	-	-	-	-	-
	Heptageniidae	97	219	2	7	45	100	3	12	11	40	-	-
Ephemeroptera	Baetidae	220	173	329	1759	130	102	325	790	51	136	347	661
	Capnidae	-	-	-	-	-	-	-	-	4	24	-	-
	Leuctridae	3	2	-	-	2	4	-	-	4	17	-	-
Plecoptera	Perlodidae	3	1	-	-	1	1	-	-	-	-	-	-
Heteroptera	Corixidae	2	20	-	-	-	-	-	-	-	-	-	-
	Dytiscidae	6	15	-	-	5	26	-	-	6	35	-	-
Coleoptera	Elmidae	32	32	-	-	7	13	-	-	-	-	-	-
	Chironomidae	189	239	187	336	290	580	339	648	661	970	261	446
	Simuliidae	11	6	6	18	50	40	190	90	101	84	217	121
	Tipulidae	30	1864	-	-	15	865	-	-	4	426	-	-
	Limoniidae	2	4	-	-	2	4	3	27	2	4	11	103
Diptera	Tabaniidae	2	149	-	-	-	-	-	-	-	-	-	-
	Hydropsychidae	13	57	-	-	2	39	-	-	2	48	-	-
	Psychomyiidae	2	18	-	-	-	-	-	-	-	-	-	-
	Rhyacophilidae	-	-	-	-	-	-	-	-	2	2	-	-
	Lepidostomatidae	-	-	-	-	-	-	-	-	35	24	7	12
Trichoptera	Sericostomatidae	11	22	6	4	7	13	-	-	-	-	2	1
Total		**1425**	**4774**	**1915**	**136840**	**821**	**3004**	**2001**	**113497**	**1121**	**1933**	**1910**	**103949**

Conclusions

The operation of the small hydropower plant located on the Karchaghbyur river affected the hydroecosystem causing changes in the qualitative and quantitative parameters of hydrobionts: in the new biotope formed by the impact of the SHP, the ecological conditions were more favorable for the growth of zooplankton, green algae, and the ecological conditions were less favorable for the growth of diatoms, as well as benthic macroinvertebrates which are the main ingredient of the feed of fishes. This can affect the growth of fishes negatively.

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REVIEW OF THE IMPACT OF ATMOSPHERIC CHEMISTRY ON CLIMATE CHANGE

BY

NNABUENYI, HELEN OKWUOMA

ABSTRACT

Atmospheric Chemistry involves the chemical activities within the region of the lithosphere that influence the climate of the earth. In global-scale, the problem is assessed by the various natural and human activities. Climate change is a yearly observatory variation, in the statistical distribution of weather for a period of time of about a decade. Factors that influence climate change, consists of the combination of physical, chemical and biological processes within a particular geographical region. These factors may be identified as natural causes that manifests by a variation in solar radiation, pattern of rainfall and concomitant vegetative variations. Human activities are possibly responsible for greenhouse gas emissions that deplete stratospheric ozone that causes the so - called atmospheric changes. The consequences arising from the global environmental changes include distorted rainfall pattern that affects agriculture, global warming and the overall climate change. This paper therefore highlights these factors that influence the global climate change with many observable climatic variations that are known to adversely afflict pains to the natural habitat, over flooding of the landscape, and global warming of the earth's surface.

Key words, Climate, Environments, Anthropology, Global warming

CHAPTER ONE

1:0 INTRODUCTIONS

As man strives for a better living through the utilization of natural resources in his environment, the atmosphere is continuously contaminated due to emissions of gases from man's activities. The contamination on a global scale is ever increasing in magnitude with concomitant implications on the ever growing human population. Climate changes in different ways over a period of time .Indeed Climate is influenced by gaseous emissions from both natural and human activities. (Demoncal P.B. 2009)

The causes of climate change according to Crooks, S. A. and Gray, L. J. (2005) include industrial and consumer releases of chlorofluorocarbons (CFCs) and other related effluents such as Sulphur, Carbon and Nitrogen Oxide related gases. Other human activities such as, combustion of fossil fuel, burning of biomass, deforestation, and green house gas release have increased and enhanced the heat trapping capability of the Earth's atmosphere. These have steadily increased the greenhouse effects with concomitant global warming as now experienced. Review has shown that all these factors alter the atmosphere and lead to climate change of Earth's surface. Evidences/disturbing aspect of climate change abound – these include: The variation in temperature records, rising sea levels, melting of ice caps of tundra regions of the northern and southern hemispheres, acid rain, etc. Changes in local condition such as rainfall pattern, collapse of dams for electricity generation, health of animals, heat stress, alteration of habitats and ecosystems cooling of stratosphere and other painful aspect of climate change. Thus the impact of atmospheric chemistry on climate change is caused by physical, ecological, social and economic activity of man in his quest for modern living.

MANIFESTATION OF CLIMATE CHANGE

. Climate change as a non-conforming behaviour of the natural elements of sun, rainfall, wind, etc. this means that of recent (past), climate deviated markedly from

old climatologist, meteorologist, scientist and grandpas knowledge patterns. Manifestation of the parameters that produce climate change helps more in understanding of effects rather than abstracts contemplation. Present rainfall patterns do not fellow the climate maps of geographical region. August "spell" has disappeared. Harmattan shows up at will and not according to prediction. (Andrew, G.2001)

Observable climate change manifestations are identifying as follows:-

i) Rise in world temperature: The first climate change is the rise of global temperature which is now seen as the Siamese twin of global warming. The world is facing a convergence of the most serious crisis in the history of the planet.

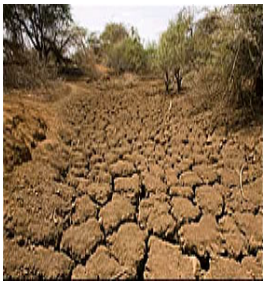
ii) Extreme change of weather by flood and drought indicators (fig3, 4, 5). Parts of England have had their wettest January since records began more than hundred years ago (BBC News Channel 30th January 2014). The floods in Assam, northern Indian state are one of the manifestations of the impacts of climate change (2012). The Ogunpa flood (Omiyale) in Ibadan South Western Nigeria of 1980s and hurricane Katrina in New Orleans, Louisiana of 2005as well as the recent flood; in New Zealand (2010) and Pakistan (2011) are quick examples of extreme weather that generates floods. Tsunami of 26th, December 2004, in Sumatra is a case in point. Tsunami is a flood that arising due to earthquakes at sea with a very high scale of destruction of life and property. Myammer (Burma) have just experience extreme weather that brought a devastiting flood. More than 100,000 persons were reported dead. Drought as a manifestation of climate change is being experienced at Nigeria where the desert is said to be advancing at 5 meters per year.

iii) Climate change equally manifests itself in the coastal zone. The world's coastal zones experience climate change in several forms. The most obvious is sea-level rise, (bar beach in Lagos and Lagos Lagoon). Global mean sea level has increased at an average rate of 1 – 2mm during the past century.

Just as flooding and advancing desert are experienced in Nigeria, and other parts of the world are experiencing one form of extreme weather or the other. The Arctic and Antarctic regions are experiencing thawing of ice which is causing flooding in some parts, The thawing of ice (fig 1), as noted above causes coastal flooding and advancement of the sea in Lagos and other states at the Costal zone of Nigeria and other country (fig.

2). At the local level, yearly flooding (fig 3) puts a strain on the budget of many states as well as Federal Governments. Massive protective works require massive funding and other badly needed services such as Education, Health, Housing and Transportation may suffer. Although, the understanding of Climate change is difficult, yet the signs and manifestation are enough to evaluate the impact of these phenomenal changes around the world.

Fig.1  fig.2  fig.3 

fig. 3  fig.4 

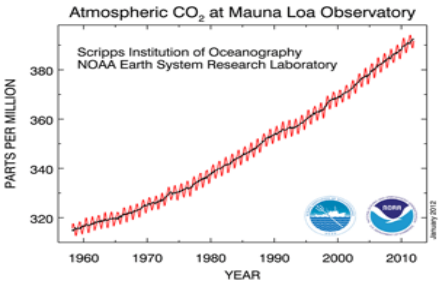


fig.5

2:0 LITERATURES REVIEW

2:1 CHEMISTRY OF THE ATMOSPHERE

Climate is the periodic accumulated data from the study of weather assessment of a specific location for any region of the world. Whereas climate describes the seasons of the year, weather is the fluctuating state of the atmosphere in a particular place that is characterized by the frequency of wind, temperature, humidity, atmospheric pressure, cloudiness, sunshine, precipitation of rain and other environmental elements. Weather is the information obtained from the measurement of these environmental parameters. Weather can change hourly, daily and even seasonal. However, the periodic statistical assessment of these daily environmental data provides the accumulated parameters for use to define the regional global climatic conditions. The data from weather defines the season from which the climatic conditions are ascribed by the latitudes in geographical maps of the world. Climate variable factors determine and influence the global climate. The climatic region is largely determined by four geographical aspects: latitude, distance from the sea, directions of the prevailing winds and elevation. Other factors that influence the global climate are: atmosphere, oceans, ice, land and various forms of life, and vegetation. Thus, geographically, the latitude unifies region of the same climate, and climate defines the type of vegetation, people, occupation and agro-activities according to Botkin D. B, and Keller, E. A. (1998).

Evidence of climate variability includes extreme amount of rain fall that causes flood and typhoons in the numerous regions of the globe. Also droughts in several countries especial in Americas are now experiencing a phenomenon called “EL-Nino”. The high temperatures of the earth, causes a bigger rate of evaporation resulting to more droughts in different areas of the world. Climate variability is different from climate change. Climate change manifests a consistent statistical distortion of the weather over a long period of time. Climate variability denotes the short term changes in climate, while climate change is considered as the long-term trend in one or more climate variable characterized by an increase or decrease of the average value during the period of record.

In realization of several parameters tied to climate, a change in climate can affect how people, plants and animals live, Also food production, availability and use of water

and health are at risk. Equally; a change in the rain fall pattern and temperature. When insects hatch or when streams are at their fullest. This can affect synchronized pollination of crops, groceries for migrating birds, spawning of fish, water supply for drinking and irrigation, forest, health, etc.

In a study by (Peterson, 2009) noted that worldwide, people are worried by climate change. The mean annual temperature of the Earth has varied by several degrees Celsius over the past million years. There is consensus among the scientists that the climate of the globe is changing. Average temperature of the globe stands now at 15.55^0C. In 1995, the temperature was 15.39^0C and said to be highest since 1860. Locally, there are severe and frequent storms, erratic and heavy rainfall, flash-floods, and river avulsion, drought and heat waves, intensified tropical cyclones and other extreme events. The trends towards powerful storms as well as longer and hotter dry periods are observed and assessed with the fourth Assessment Report of IPCC (2007). Climate Change is really taking a toll on us. The warmer temperature means that a lot of evaporation and a warm atmosphere will not be able to hold a lot of moisture so more waterfall into the earth as precipitation. In addition, dry regions are to lose much moisture if the weather tends hotter. This means more droughts and desertification. High precipitation events have been observed within the eastern parts of South and North America, central and Northern Asia and Northern Europe. Drying has been observed in large regions such as the Mediterranean, part of South Asia and South Africa.

Furthermore, the total available waters in Africa's big basins such as Lake Chad, Senegal and Niger decreased by 40 to 60%. Also reports indicate a worsened desertification by low average annual soil moisture, runoff and rainfall especially in northern, western and southern Africa. Eastern European floods of 2002 and Mozambique floods in 2000 are just examples of powerful storms and climate impact due to climate change.

2.2 LITHOSPHERIC CHEMISTRY ON GLOBAL WARMING

Trace gases present in the atmosphere are measured in ppmv (10-6), ppbv (10 – 9) and at times pptv (10 – 12) these gases are known to contribute to changes in the chemistry of the atmosphere and Earth's climate. It is also evident that the chemistry and climate control factors are increasing in concentration with time. Typical of these greenhouse gases are Carbon (IV) Oxide Methane (CH_4), Nitrous Oxide (N_2O), Sulphur (IV) Oxide (SO_2) and troposphere Ozone (O_3) which are all increasing with time. In addition, more chemically active gases, i.e. Nitrogen monoxide (NO) and Carbon monoxide are also increasing in their emissions from human activities. There are varied sources of production of these gases which include:

*The burning of fossil fuels: Sources of Carbon and Nitrogen Oxide series, CO_X and NO_X (X = 1, 2)

*Microbial, metabolic activity (CH_4, N_2O and NO

*Photochemical reactions (O_3) and

*Industrial effluent gases (CO_2, H_2S, CO, NO, SO_2 etc. Including, automobile exhuse.

These gases, according to Onuchukwu et al (2002) are produced directly by biomass burning, i.e. the clearing and burning of the forests and savanna grass lands for agriculture, the burning of agricultural waste and the burning biomass for fuel. Interestly, biomass burning is more extensive than previously contemplated. Regrettably, much of the global biomass burning is done by human activities. This practice is very much carried out in developing countries. It could be adduced that biomass burning may be an important cause of global change in the atmosphere as well as Earth's climate. Also, there are some natural releases of these greenhouse gases especially during volcanic eruption. The microbial decomposition of biomass and animal remains, gas flaring in production industries are yet another larger emissions of these greenhouse gases.

2:3 CAUSES OF CLIMATE CHANGES

Allison .I. G. (2007) emphasized that, to understand climate change fully, the causes of climate change must first be identified. Scientists categorized the causes into two, namely: (a) Natural and (b) Human Causes.

2.3 (a) Natural Causes of Climate Change

The earth's climate is influenced .by natural causes. These include the following:

(i) **Volcanic eruptions –** A volcanic erupts is known to throws up lava that contain Sulphur (IV) Oxide gas, dust and ash into the atmosphere. These emissions do influence the weather patterns for years by increasing planetary reflectivity

causing atmospheric cooling. These tiny particles referred as aerosols from volcanoes reflect energy back into space, causing a cooling effect on earth's surface. The greenhouse gas, Carbon (IV) Oxide is also produced, but the amount emitted is insignificant compared to other related emissions created human activity.

(ii) Ocean current – The Ocean is a major component of the climate system. Ocean currents move vast amount of heat across the planet. Winds push horizontally against the sea surface and drive ocean current patterns. Interaction between the ocean and atmosphere may also give rise to El Nino which occurs every two to six years. These are deep oceanic circulations of cold water from the poles towards the equator and movement of warm water, from the equator back towards the poles. Without this movement, the poles would become colder while the equator is warmer. The ocean currents play an important role in determining the atmospheric concentration of Carbon (IV) 0xide. Changes in ocean currents affect the climate change through movement of Carbon (IV) Oxide into or out of the atmosphere. Botkin,D.B.and Keller,.E.A.(1998).

(iii) The earth orbital rotation – The Earth makes one full rotation around the sun each year. It is tilted at angle of 23.5^0C to the perpendicular plane of the orbital path. For half of the year, such as in summer, the northern hemisphere tilts towards the sun while the other half experiences the winter as the earth is tilted away from the sun. (See Fig. 2.6). The tilting/rotation of the earth the round the air is responsible for the manifestation of seasons. The earth orbital rotation is near elliptical, which means that the distance between the earth and the sun varies over the course of one year. This gradual change in the duration of the earth's axis called procession and is responsible for changes in the climate.

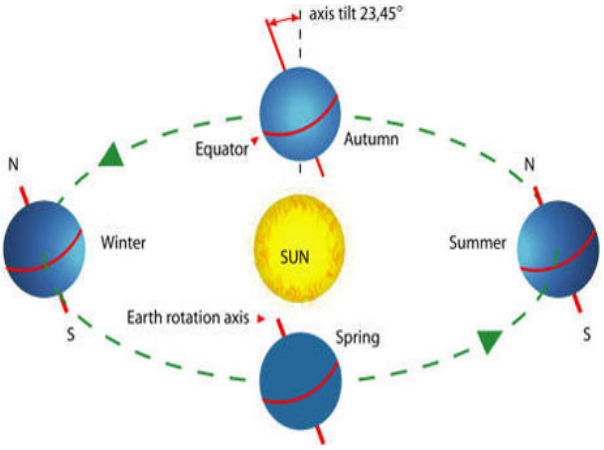


Fig: 2.6

Showing the orbital rotation and revolution of the Earth around the sun given rise to

a) Day and Night

b) Seasons respectively

2:3(b) HUMAN CAUSES OF CLIMATE CHANGE

Anthropogenic factors are human activities that cause climate change. Recently, there is a release of the fourth assessment Report, by the Inter-governmental panel on climate change (IPCC, 2007). This group of 1,300 independent experts on climate change from countries all over the world under the auspices of the United Nations Environmental Protection (UNEP) concluded that there is more than 90% probability implicating human activities over the past 250 years as the cause of global warming.

Human activity from the period of the industrial revolution has increased the amount of greenhouse gases in the atmosphere, by the emission of Carbon (IV) Oxide, Methane and depletion of troposphere ozone by chlorofluorocarbons and nitrous oxide. Fossil fuel, such as, coal and natural gas are the energy needed to run vehicles, generate electricity for industries. Combustion of the fossil fuel releases greenhouse gases. Lands that were covered with vegetation have been cleared to make way for houses, agriculture which releases Carbon (IV) Oxide through biomass decay. Natural resources are being used extensively for construction, industries, transport and consumption. Other factors including ozone depletion, deforestation, land degrading which release carbon from the land system and reduce its capacity to absorb and store

carbon. Burning biomass also releases aerosols and other pollutants into the atmosphere, changing its capacity to reflect or absorb solar radiation. These aerosols may also be deposited on land and cause changes to the surface albedo. (IPCC, 2007).

Apart from the utilization and transformation of these natural resources by man, the products and waste products from these transformations contribute separately and jointly to the factors that affect the climate.

(i) THE EFFECT OF GREENHOUSE GASES

An environment impact due to the presence of these greenhouse gases, namely: Carbon (IV) Oxide, Methane, Nitrous Oxide, fluorinated gases and other trace gases radiation (fig2.7).

The main greenhouse gases

Greenhouse gases	Chemical formula	Pre-industrial concentration	Concentration in 1994	Atmospheric lifetime (years)***	Anthropogenic sources	Global warming potential (GWP)*
Carbon-dioxide	CO_2	278 000 ppbv	358 000 ppbv	Variable	Fossil fuel combustion Land use conversion Cement production	1
Methane	CH_4	700 ppbv	1721 ppbv	12,2 +/- 3	Fossil fuels Rice paddies Waste dumps Livestock	21 **
Nitrous oxide	N_2O	275 ppbv	311 ppbv	120	Fertilizer industrial processes combustion	310
CFC-12	CCl_2F_2	0	0,503 ppbv	102	Liquid coolants. Foams	6200-7100 ****
HCFC-22	$CHClF_2$	0	0,105 ppbv	12,1	Liquid coolants	1300-1400 ****
Perfluoromethane	CF_4	0	0,070 ppbv	50 000	Production of aluminium	6 500
Sulphur hexa-fluoride	SF_6	0	0,032 ppbv	3 200	Dielectric fluid	23 900

Note : pptv= 1 part per trillion by volume; ppbv= 1 part per billion by volume, ppmv= 1 part per million by volume

* GWP for 100 year time horizon. ** Includes indirect effects of tropospheric ozone production and stratospheric water vapour production. *** On page 15 of the IPCC SAR. No single lifetime for CO_2 can be defined because of the different rates of uptake by different sink processes.**** Net global warming potential (i.e., including the indirect effect due to ozone depletion).

GRID Arendal UNEP

Source: IPCC radiative forcing report ; Climate change 1995. The science of climate change, contribution of working groupe 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

Light and ultraviolet radiations from the sun are able to penetrate the atmosphere and warm the earth's surface. This energy is reflected as infrared radiation, because of its longer wavelength, is absorbed by such substances as Carbon (IV) Oxide. (See table 2.1).

Onuchukwu, Onuoha and Ejele (2002) pointed out that although many greenhouse gases occur naturally, through burning fossil fuel, bushing burning, gas flaring and other human activities, (i.e. industrial gases released). The burden of Carbon (IV) Oxide level is reported to have increased from a pre-industrial revolution level of 280 ppmv to more than 350 ppmv today at a rate of about 0.5% per a year. The

Chlorofluorocarbons (CFC), a type of compound in which some or all of the hydrogen atoms of a hydrocarbon, (usually an alkenes) have been replaced by chlorine and fluorine. Most Chlorofluorocarbons are chemically unreactive and are stable at high temperatures. The most widely used chlorofluorocarbons are Dichlorodifluoromethane (CCL_2F_2) and Trichlorofluoromethane (CCL_3F). These colourless, odourless compounds are often identified in industrial short hands molecule FC – 11 (CCL_3F) and FC – 12 (CCL_2F) with a prefix such as propellant – 12 or refrigerant – 12 which identifies its intended use or a trade name such as Freon – 11 or Freon 12, a mixture of FC – 11 and FC – 12 make an effective propellant for aerosol sprays, as a solvent and FC – 11 is a blowing agent in the manufacture of plastic foams etc. FC – 11 and FC – 12 are photo decomposed in the stratosphere to release nascent chlorine atom plus a residual radical:

$CCI_2F_2 \longrightarrow (Cl) + CClF_2$ (2.1)

Dichlorodifluoromethane Chlorodifluoromethane

$CCI_3F \longrightarrow Cl + CCl_3F$ (2.2)

Trichlorofluoromethane chlorine radicule

This photo chemical reactions, cause a break down that reacts with ozone Onuchukwu et al (2002).

The uses of refrigerant in refrigerators for example bring about three greenhouse gases. These are CFC – 12 (refrigerant), CFC – 11(from the insulation of the refrigerator) and finally Carbon (IV) Oxide (from the energy generated to run the system). Thus, the U. S. Department of Energy (DOE) identified the direct contribution of Carbon (IV) Oxide emissions resulting from the energy required to run the system over its normal life. Both, must be considered when determining the total global warming on the system. The sum of the direct and indirect emissions of greenhouse gases represents the total equivalent warming impact (TEWI)

(ii) ACID RAIN

Thermal power plants, industries and related sources release daily quantum of Oxides of Nitrogen and Sulphur into the atmosphere. Botkin, D. B. and Keller, E. A. (1998) reported that, these gases undergo reactivity in the atmosphere and form Nitrates, sulphates, and their acids with water vapour . Some pollutants, especially the Oxides of Sulphur could travel 200 – 300 km in a day. Thus, the compounds emitted at a place may be carried hundred of kilometers by the wind and deposited on land and on vegetation to form directly as "acid rain" by the reactions:

H_2O (l) + SO_2 (g) $\longrightarrow$ H_2SO (l) (2.3)

SO_3 (g) + H_2O (l) $\longrightarrow$ H_2SO_4 (2.4)

Similarly, Nitrogen Oxide undergoes same reaction

NO_2 (g) + H_2O $\longrightarrow$ HNO_3 (2.5)

Though rain is expected as the purest water source, but absorbs the atmospheric Carbon and Sulphur in air to form these acids: H_2CO_3 and H_2SO_3 with pH falling from 7.0 of neutral water to pH < 4. As the pH of water falls below 5.6 is termed as "Acid rain". Acid rain means any precipitated rain, snow or dew, which is more acidic than normal.

About 70% of the acidity of an acid rain is due to SO_x emission and 30% due to NO_x emissions. Majority of the fuels especially coal contains about 80% of Nitrogen about 20% of Oxygen, and huge quantities of SO_x and NO_x are released. The super stack and the mammoths' meters at Sudbury of Ontario release about 2500 tonnes of SO_2 everyday. This largest stack of the world alone contributes about 1% of the total SO_2 released. Onuchukwu, et al. (2002).

Acid rain is deleterious to the environment. This may distort the ecological balance on a global scale. Increase in the acidity leads to the death of aquatic organisms like green algae, bacteria, prevents the hatching of fish and destroy trout, and trees are adversely affected. Beneficial micro-organism are killed or reduced. Earthworm (farmer's friend) cannot survive in acidic environment.

At low pH, decomposition of organic matters is less resulting in the accumulation of organic matters in water bodies. The concentration of heavy metals such as lead, Cadmium, Copper, Zinc, Aluminum etc, increases while plants nutrients like Potassium are leached out of soil. All this decrease soil fertility and self purification capacity of water body, and increases the degree of water body and water pollution. These affect the quality of water. Acid rains corrode buildings monuments, status, bridges, fences, railing and art treasures. It is an irreparable loss to mankind. (Weathers, K. C. and Lukens, G. E., 2006).

The remedial measure of the control of acid rains suggests minimization of emissions of the Oxide series of Carbon, Sulphur and Nitrogen from industries and power source using proper control equipment and stringent legislations. Periodic application of lime to neutralize acidity is a solution, but could be expensive.

The cycle of formation of Acid rain from Sulphur (IV) Oxide (Weather,K.C. and Lukens, G.E., 2006).

(a) $SO_2\,(g) + \frac{1}{2}\,O_2\,(g) \longrightarrow SO_2\,(g)$ (2.6)



$H_2O\,(l)$ $H_2O\,(l)$

$H_2SO_3\,(l) + \frac{1}{2}\,O_2\,(g) \longrightarrow H_2SO_4\,(l)$ (2.7)

(b) $CO + [O] \longrightarrow CO_2$

$[O] + H_2O \longrightarrow H_2O\ [\uparrow]$ (2.8)

$H_2CO_3 \longrightarrow H_2O + CO_2$ (2.9)

(iii) STRATOSPHERIC OZONE DEPLETION

The Ozone –This is a gas, with three atoms of oxygen and chemical formula (O_3). Ozone forms a natural blanket layer high in the stratosphere. This ozone blanket protects humans from excessive ultraviolet radiation from the sun. Ozone is considered a pollutant when present above the National Air Quality Standards threshold concentration, in the lower atmosphere but is beneficial in the stratosphere, (IPCC, 2007).

The earth has a protective umbrella in the form of ozone blanket, of about twenty-four kilometer thickness in the stratosphere. This is about fifteen kilometers away from earth's surface with concentration about ten ppm compared to 0.05ppm in the troposphere. Higher ozone concentration in the troposphere are injurious to man and vegetation, whereas stratospheric ozone layer is essential for the sustenance of life on earth. The ozone layer absorbs the dangerous ultraviolet radiation from the sun and converts it to heat. This activity is responsible for the rise in temperature. (See equation 2.10 -3.2). This increase in ozone is of concern because ozone present in the upper troposphere act as a greenhouse gas, absorbing some infrared energy emitted by the sun. Quantifying the greenhouse gas potency of ozone is difficult because it is not present in uniform concentration across the globe.

The Ozone is formed by photochemical reaction by the equation.

$$O_2\,(g) + [O] \xrightarrow{hv} O_3\,(g) \qquad (2.10)$$

A reverse reaction occurs as oxygen molecule absorbs ultraviolet radiation with wavelength greater than 290nm.

$$O_3\,(g) + [O] \longrightarrow 2O_2\,(g) \qquad (2.11)$$

The later reaction equation (2.6) is catalyzed by the presence of certain free radicals of which the most prominent are OH, NO, Cl, Br, CFCs etc. These radicals deplete the stratospheric ozone by the photoreaction.

$$CFCC_3 + Uv \xrightarrow{hv} CFCl_2 + Cl \qquad (2.12)$$

$$Cl + O_{\cdot} \longrightarrow ClO + O_2 \qquad (2.13)$$

$$ClO + O \longrightarrow Cl + O_2 \qquad (2.14)$$

The free chlorine atom BEING CATALYST is free to attack another ozone molecule

$$Cl + O \longrightarrow ClO + O_2 \qquad (2.15)$$

$$ClO + O \longrightarrow Cl + O_2 \qquad (2.16)$$

And again……..… for thousands of time

When ultraviolet light waves (UV) strike CFC molecules in the upper atmosphere, Carbon – Chlorine bond breaks, producing a chlorine radical (equation 2.14), the chlorine radical then reacts with an ozone (O_3) molecule (equation 2.15) breaking it apart and so destroying the ozone. This forms an ordinary oxygen molecule (O_2) and a chlorine monoxide (ClO) molecule (equation 2.16). Then free Oxygen radical breaks up the chlorine monoxide (Fig2.17). The chlorine radical is free to repeat the process of destroying more ozone molecule. A single CFC molecule can destroy 100,000 ozone molecules (IPCC, 2007).

As a result of these reactions above ozone layer is thinned down. The patches of thinned ozone layer are known as "Ozone holes". The ozone hole is a thinning of the stratosphere's ozone layer, which is roughly 9 to 31 miles above the earth's surface. The depletion of this ozone layer, creating ozone hole lets more harmful ultraviolet (Uv) radiation reach the earth's surface. This problem is now worrisome. In consequence, countries around the world agreed to stop the manufacture and use of Chlorofluorocarbons as a refrigerant. This international agreement is called "the Montreal protocol". (1987).

2.4 IMPACT OF CLIMATE CHANGE

2.4 (i) GLOBAL TEMPERATURE RISE

All three major global surface temperature reconstructions show that the Earth has warmed up since 1800. James, R. L., 2010 noted that most of this warming has occurred since the 1970s, with the twenty warmest years having occurred since 1981 and with all ten of the warmest year occurring in the past twelve years. Even though the 2000s witnessed a solar output decline resulting in an unusually deep solar minimum in 2007 and 2009, surface temperatures continue to increase. High temperatures have started warming the ocean, increase carbon (1V) dioxide and acidity of the ocean. Melting polar ice caps, ice bergs and glaciers. All these may

reduce crop production there by causing famines, intense rainfall are predicted which leads to flooding (parry,M.Land Rosenzweigh,C.2009).

This would lead to huge expenditure by governments and individuals to safeguard property from surging. Submerging low lying coastal countries examples Denmark, Bangladesh and recently some countries like Pakistan would also experience conversion of freshwater habitat and ecosystems into saltwater areas, endangering vegetations, crops, animals and water supply along the coast.

(ii) GEN**ERAL VEGETATION OF THE WORLD**

Vegetation is an important and highly visible element of the natural and cultural environment. Vegetation has significant relationship with climate, water, soil landforms, plants, (dendroclimatology, pollen analyses), animals (migratory insect/birds) and humans. Indeed, Geographers often proclaim that vegetation is "the minor of climate". Comparing a world vegetation map with a world climate map in any good atlas clearly shows that specific categories of vegetation are associated with certain types of culture. At regional and global scales, there is predictability of certain vegetation characteristics, especially, physical ones, which are related with the environmental predictability in certain regions. (Allison, G.2007).

(iii) IMPACT OF CLIMATE CHANGE ON THE ENVIRONMENT

There is a considerable impact of climate change on the environment. These consequences of climate change could be devastating on the environment. If the action plan is not taken to reduce the effects, then, evaporation will increase as the earth warms up and there will be increase in average global precipitation. Local climate conditions are changing depending on the modifications of local rainfall pattern. Water availability for irrigation, industrial use, electricity generation and the aquatic habitat may be significantly affected.

Soil moisture content is likely to drop affecting crops and the need for irrigation. The high temperature may reduce crop production, thereby causing famines, intense rainfall is also predicated. Tropical rains, hurricanes and typhoon will be more frequent and stronger. Increased rainfall may cause frequent flooding. Climate change would likely add stress to major river basins worldwide (IPCC, 2007).

(iv) COOLING OF STRATOSPHERE

The report of Ruddiman, W. F., (2003), on anthropogenic greenhouse gases noted that the increase in concentration of greenhouse gases, are expected to cause cooling of stratosphere. This is expected because, most of the infra-red radiation is trapped and absorbed at lower latitudes, and left over of this radiation warms the stratosphere. Thus, the cooling of the stratosphere means an enhanced greenhouse accumulation that is responsible for increased global warming.

(v) DEVELOPMENTS

Increase, temperature rise with the combined effects of global warming may result to harsh effect on people with reduced work efficiency. This may slow down economic development with, increased hunger, disease and unemployment among population. This will negate governments fight against poverty reduction and achieving the millennium development goals (MDGS) becomes unrealisable.

(vi) EFFECTS OF CLIMATE CHANGE ON AGRICULTURE

The study of Bachelet et al, (2001) that climate change is expected to have a mixed effect on agriculture, with some regional benefits from moderate temperature increases and as well as negative effects due to flooding from heavy down pour of rains. Low latitude areas are at most risk of suffering decreased crop yield. Mild and high latitude areas could see increased yields for temperature increases of up to 1 – 3^0C. This is possibly due to global warming that may extend the cropping season, by allowing early planting crops in the spring, with earlier maturing and harvesting. There is possibility of completing two or more cropping cycles during the same season. Agricultural activity of any kind is strongly influenced by the availability of water.

Climate change may affect the pattern of rainfall, evaporation, and soil moisture. These factors may affect flowering, pollination and grain filling of most crops. Hence, there is need to select crop varieties with greater climate variability tolerance, for better yield. Application of fertilizer may be needed to mitigate these processes in order to enhance crop growth with attendant environmental risk.

Warmer climate condition is more favourable for the emergence of insects such as grasshoppers, locust, etc to complete a greater number of their reproductive cycle for possible infestation. Greater used of chemical pesticides to control them, will require further development and application of integrated pest management techniques.

(vii) HEALTH IMPACT FROM ASSESSMENT

With warmer temperatures and higher humidity, hot and excruciating weather is expected in many areas around the world. Heat stress shall occur in such conditions and the people are more susceptible to the discomfort. Air pollution, changes in food and water supplies etc, will also affect human health. Changing patterns of precipitation and temperature variation may produce favourable breed sites for vectors, pests with emergence of infections and diseases. According to the inter-governmental panel on climate change (IPCC, 2007); the balance of positive and negative health impacts will vary from one location to another. Adverse health impacts will be greater in low income countries of the world.

The negative health impacts of climate change will outweigh the benefits especially in developing countries. Some examples of negative health impacts include: increased malnutrition, deaths, injury, and extreme weather events and natural disaster, increase in climate sensitive infections diseases, and air pollution. In addition there are related illness and injury due to heat waves, floods, storms, fires, drought and cardio-respiratory diseases.

(viii) ECOSYSTEMS AND ALTERATION OF HABITATS

Many of the world's habitat and ecosystem depend on a delicate balanced rainfall, temperature and appropriate soil type. A complex food chain supply exists based on these factors. Unchecked global warming could affect most terrestrial eco-regions. Increased global temperature means that ecosystem may change. There may be increase in forest susceptibility to fire, diseases and insect extinction; deserts may expand into existing grassland. Some species are being forced out of their habitats because of changing conditions, while others are flourishing. Secondary effects of global warming such as lessened snow cover, rising sea levels and weather changes may influence not only human activities but also the ecosystem. Scientists predict that global temperature for the coming centuries may trigger off new mass extinction events, reduced diversity of ecosystem. Over 50% of animals, plants and marine life may not adapt quickly enough and may to go extinct. (Bachelet, et al., 2OO1)

(ix) LAND USE PATTERNS

The land use patterns contribute to climate change. Trees and other plants use Carbon (IV) Oxide and give off Oxygen. When trees are cut down for development, agriculture and other purposes, they are no longer available to take Carbon (IV) Oxide out of the air and actually release Carbon (IV) Oxide as they decay or burn.

As the levels of Carbon (IV) Oxide and other greenhouse gases increase more heat is trapped to produce global temperatures rise. This causes significant changes in the timing and length of the seasons as well as the amount and frequency of precipitation.

2.5 ENVIRONMENTAL POLICY AND PROTOCOL

These involve possible policies put in place for the control of climate change. The first movement is to admit that our climate is undergoing actual change and understanding the causes of climate change is desirable. Some scientists and nonscientist still question the aspects and reality of climate change. But one should realize that people who are addicted to fossil fuels are known to produce large volume of Carbon (IV) Oxide gas. Industrial, agricultural and other developmental activities lead to the release of other global warming gases.

The mitigation of climate change is proposed as follows:

The most recent is the Carbon capture and storage (CCS).A sequestration reaction (The combing of metallic ions with suitable reagents in solution to prevent a particular reaction) yield chelated complexes, used to prevent the chemical effect of anion without removing it from the solution. According to Karl Jeffery member Carbon (IV) Oxide capture project organization, and Editor Digital Energy Journal, Carbon capture sequestration is a means of mitigating the contribution of fossil fuel emission to global warming. The process is based on capturing Carbon (IV) Oxide from large point source, such as fossil fuel, power plants and storing it in such a way that Carbon (IV) Oxide does not enter the atmosphere. Some of the methods of sequestration include

i) Geological sequestration
ii) Oceanic sequestration
iii) Mineral and biological sequestration
iv) Terrestrial sequestration

Numerous sequestration schemes are possible, some commercially available at present but all are very expensive. Many countries, both developed and developing are aiming to adopt cleaner, less polluting energy sources technologies. Thus, the adoption of these alternative energy sources is expected to reduce substantially the emission of Carbon (IV) Oxide gas. Polices include targets for emissions reductions, increased energy efficiency, by renewable energy resources are bio-energy, hydro-electrical energy, solar energy, geothermal energy etc. Studies indicate that for substantial potential future reductions in emissions, individual's contributions like planting of tree and other human actions that endangers ecosystem and resources conservation must stop.

Other policy responses include Adaptation to climate change. Under this strategy people find ways to live successfully within the changed climates. Planned adaptation is already occurring on a limited basis, land use may change, aqua ducts can be built to bring water into newly dry areas, and coastal population can be protected from rising sea level by building dikes and seawalls. The barriers, limits and cost of future adaptation are not fully understood.

Developing and developed countries have posed different arguments over who should bear the burden of costs for cutting emissions. They Kyoto protocol, came into force in 2005, sets legally binding emission limitations for most developed countries but developing countries are yet to be subjected to these limitations.

Most countries are parties to the United Nations Framework Convention on Climate Change (UNFCCC). The Ultimate Objective of Convention is for the prevention of "dangerous" human promotions of the climate change. This requires that greenhouse gases' (GHG) are stabilized in the atmosphere at a level where.

(i) Ecosystems can adapt naturally. (ii) Food production is not threatened.

(iii) Economic development could be sustained.

By the Kyoto Protocol to the UNFCC, developed countries took legally binding commitments to reduce their emissions. At the 15^{th} UNFCC Conference of the parties, held in 2009 at Copenhagen, several UNFCC parties produced the Copenhagen Accord. Parties agreeing with the accord, to limit the future increase in global mean temperature to below 2^0c.

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A SHORT BIO-DATA OF THE WRITER

Nnabuenyi, Helen Mrs. is a lecturer at federal Polytechnic Okoh in Orumba North Local Government, Anambra State, Nigeria.She studied Analytical Chemistry, at both frist degree and masters level at Nnamdi Azikiwe University Awka,Anambra state.She is a native of Abatete, married and blessed with four kids.

Currently, she is running her Ph.D. programme at Anambra state University Awka on Physical and Material science Chemistry. She is the author of Essential Chemistry Text for Polytechnic Students and co author of Basic Practical Chemistry. She had many publications in both local and International Journals.

Trend Analysis and Modeling of Energy Consumption in Arid Environments: The Case Study of Qatar

Rita Chamoun[*1], Rania Bou Kheir[2]

[*]*Qatar Environment and Energy Research Institute, Qatar Foundation, P.O.Box 5825, Doha, Qatar.*

Lebanese University, Faculty of Letters and Human Sciences, Department of Geography, GIS Research Laboratory, P.O. Box 90-1065, Fanar, Lebanon.

[1] rchamoun@qf.org.qa

[2]prof.boukheir@gmail.com

Abstract

Energy consumption in Qatar has more than doubled during the last decade and the reasons behind this fact need to be studied. This paper presents, in a first part, an insight into the energy consumption breakdown and a trend analysis of the energy production, energy consumption, population and GDP, based on the country's historical data. In a second part, this study proposes a regression-tree model to predict the impact of different variables such as population, GDP, electricity consumption, electricity production and primary energy production, on the primary energy consumption in Qatar (as a case study of Arid landscapes). The developed tree-model explained 95% of variance in energy consumption using primary energy production (100% in relative importance), GDP (40%), and population (25%). The proposed tree model is relatively simple and may also be applied to other areas.

Keywords— Energy, Consumption, Modeling, Trend, Decision-Tree, Qatar.

I. INTRODUCTION

The continuous increase of energy consumption has become a worldwide issue necessitating a great deal of attention from governments and regulatory bodies. Global energy consumption has approximately increased by 80% between 1970 and 2004. In 2011, the world's total primary energy consumption reached 12274.6 Mtoe [1]. During the same period of time, the global income and population growth have increased by 77% and 69% respectively [2]. Hence, several studies have been conducted to show that the increasing demand for energy in many countries is well related to the economic development and population growth [3]-[5].

As for Qatar, total energy consumption increased by 140% between 2001 and 2011 [1]. Therefore, in order to understand the reasons for this rapid growing demand and for good energy management in a fast developing country like Qatar, a trend analysis and a modeling study predicting the main parameters behind the increase of primary energy consumption are needed. Conventionally, regression analysis has been widely used as modeling technique in predicting energy consumption [6]–[10]. Artificial neural networks have also been used for the same [11] as well as decision tree methodology that was found to be an efficient decision support for a prediction system [12].

Although the machine learning, probabilistic, non-parametric, decision-tree method has been seldom used for the prediction of energy consumption, it is essentially an exploratory method [13], and it has been used predictively [14] without the need of specifying data-fitted form function. It has been extensively exploited for vegetation mapping [15], ecological modeling [16], gully erosion modeling [17], soil mapping [18],[19], epidemiological monitoring [20], and remote sensing studies such as land-use classification based on threshold values of various band data [21],[22]. However, the potential of regression trees to contribute in the field of energy consumption has received little attention, especially in the arid environments.

This study uses a statistical regression decision-tree model that in a simple, realistic and practical way predicts the distribution and variation of primary energy consumption, based on the analysis of anthropogenic and socio-economic parameters (predictors) such as population, GDP, electricity consumption, electricity production, and primary energy production that are likely to impact the energy consumption and quantification of their weights in a study area across Qatar. The obtained tree results can serve as useful tool for energy planning in Qatar.

The first part of this paper presents an insight into the energy consumption breakdown and a trend analysis of the energy production, energy consumption, population and GDP, based on the country's historical data. The second part shows the developed regression-tree model used to predict the impact of different variables on the primary energy consumption in Qatar.

II. BREAKDOWN AND ANALYSIS

A. Background and Energy Consumption Breakdown

Qatar is a peninsula located on the western coast of the arabian Gulf with a total area of 11606.8 km2 and a coastline length of more than 700 km including islands [23]. The industrialization and infrastructure development has contributed to a population growth going from 0.4 million in 1990 to more than 1.8 million by 2012 [24]. The population density was 138/km2 in 2009 and today it is estimated to be more than 150/km2 where more than 96% are located in urban areas [23], [24]. Such statistics are important for good energy management since an increase in the populaton will definitely lead to an increase in electricity, water and energy demand.

Qatar's economy depends mainly on the petroleum industry and its oil and gas production and export, which accounts for more than 70% of the government's revenue, not less than 50% of the country's gross domestic product (GDP) and around 85% of its export earnings. In addition, Qatar is wholly dependent on oil and natural gas for all of its primary energy consumption. Demand for oil is still increasing due to the growth in the country's transportation sector, at the time when all electricity generation is fueled by natural gas.

In 2011, Qatar produced around 76.7 million tons of crude oil and 134.6 million tons of oil equivalent (Mtoe) of natural gas. More than 66% of the oil output and 78% of that of natural gas were exported and the rest was consumed locally [25]-[29]. During that year, total primary energy consumption was almost 27.5 million tons of oil equivalent. Natural gas consumption accounted for around 70% of the total energy consumption and the remaining 30% was due to the use of petroleum products [29].

The largest portion of the oil products went to the transportation sector which accounted for 63% of the total final consumption in 2011. That was followed by 26% going for petrochemical feedstocks and 10% for industry use, keeping just 1% for residential use (Fig. 1) [27].

Natural gas in Qatar is either used as a primary energy (75%) or as final product and feedstock (25%). Gas consumption totaled 19.5 Mtoe in 2011. Around 38% of the consumed natural gas goes for energy industry own use, 27% are consumed as primary energy for fueling electricity generation plants, and 25% of the total locally consumed gas goes for industry as final product and feedstock. The rest (10%) are used for other purposes such as liquefication plants (Fig. 2) [25], [28].

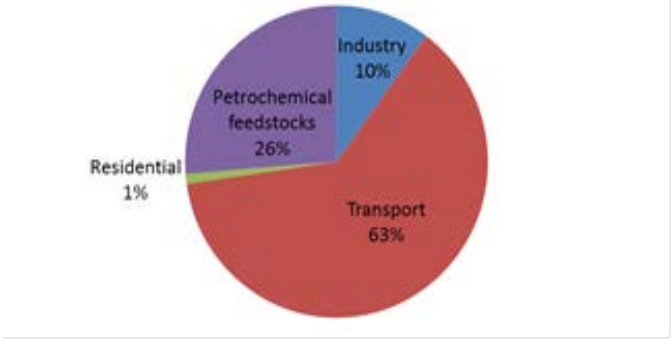


Fig. 1 Oil final products consumption by sector in Qatar in 2011 [26]

The only form of secondary energy produced in Qatar is electricity. The country currently has an installed power generation capacity of 4.89 Gegawatts (GW), which is 100% gas-fueled. In 2011, a total of 30.73 billion kilowatt-hours (Kwh) of electricity was generated [30]. Almost all electricity produced is locally consumed, with very minor quantities exported through the GCC power grid since the late years of the last decade. The power generation and water desalination industry used approximately 8% of the yielded product, while losses in the transmission and distribution network grid accounted for about 2%. The rest of electricity produced was consumed as final product by industry (30%), and domestic sector including residential and commercial buildings (60%) [15].

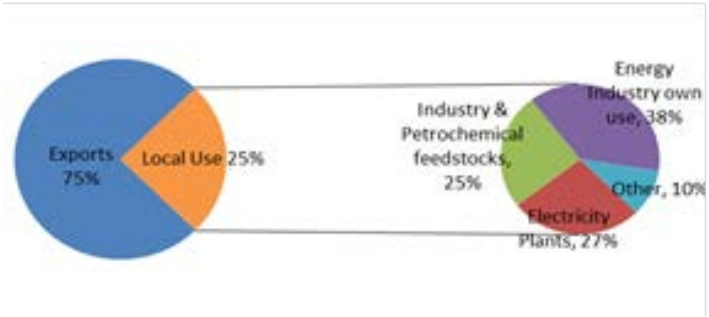


Fig. 2 Natural gas consumption by sector in Qatar in 2011 [28]

B. Trend Analysis

1) Energy Production and Consumption

The total primary energy production and consumption in Qatar has been increasing from 1985 till 2009 and it is clearly noticed that the production of energy exceeds by far the consumption (Fig. 3). This was mainly noticed after large natural gas reserves have been located off Qatar's northeast coast which boosted the production and export of gas products starting from 1996 and became today the world's largest LNG exporter.

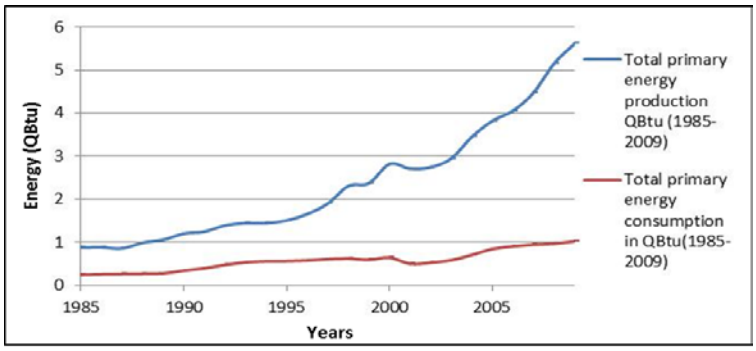


Fig. 3 Total primary energy production and consumption (1985-2009)

Year	TEP (QBtu)	Growth Rate (%)	TPEC (QBtu)	Growth Rate (%)
1985	0.87		0.24	
1991	1.24	2.3	0.39	7.3
1996	1.65	4.7	0.57	10.6
2001	2.71	13.5	0.50	2.8
2006	4.05	6.5	0.90	6.8
2009	5.61	10.1	1.02	4.9
	Growth Rate of TEP (%)		**Growth Rate of TPEC (%)**	
1985-95	5.72		9.01	
1996-09	10.07		4.87	
1985-09	8.26		6.60	

Table 1 Growth rate of total energy production (TEP) and total primary energy consumption (TPEC) in Qatar (1985-2009)

From Table 1, it is clear that the growth rate of consumption exceeds that of production from 1985 till 1995. But the scenario changed from 1996 with the discovery of the third largest natural gas reserves in Qatar and in due time period, the rate of growth of energy production moved faster than that of energy consumption.

2) Primary Energy Production

It is clear from table 1 that the production of energy has considerably increased from 1985 till 2009. The highest growth rate of energy production (13.5%) was recorded for the period 1996-2001. This was mostly due to the development of the North Field gas where Qatargas started in 1996 the export of Liquefied Natural Gas (LNG) to Japan. The second highest growth rate of 10.1% was recorded during 2006-2009 period. However, other time periods has not recorded rapid growth rate. The decrease in growth rate between 2001 and 2006 might be attributed to the weak performance of the country's economy due to the decrease of oil prices during the beginning of spring 2001.

The political changes that took place in the country in 1995 may have also affected the economic activity. In fact, the results show that the growth rate of the production increased rapidly between 1996 and 2009 (10.07%) compared to 1985-1995 (5.72%). The growth rate from 1985 to 2009 (8.26%) was slower than that from 1996-2009 but still higher than the growth rate from 1985 to 1995 (Fig. 4). During the timeframe 1996-2009, the country has started developing and many economic, social and demographic reforms have occurred in that time which may be one of the reasons that the production rate of the energy resources was more rapid from 1996 to 2009 compared to other time period (1985-1995).

3) Primary Energy Consumption

As shown in Table 1, energy consumption has been increasing since 1985, except for the year 2001 where the total primary energy consumed decreased slightly. This decrease might be due to the global economic effects arising from the September 11 attacks in New York. Nevertheless, the calculated growth rate for the different time periods is positive and the highest rates observed are for the periods 1991-1995 (10.6%), 1985-1990 (7. 3%) and 2001-2005 (6.8%) (Table 1). The growth rate was found to be faster for 1985-1995 (9.01%) compared to 1996-2009 (4.87%). The overall growth rate from 1985 to 2009 in consumption is calculated to be 6.6% (Table 1). The consumption was more rapid in the first phase compared to the second as well as compared to the overall growth rate. Hence it can be said that in the developing process from 1985 to 1995 there has been more rapid energy consumption.

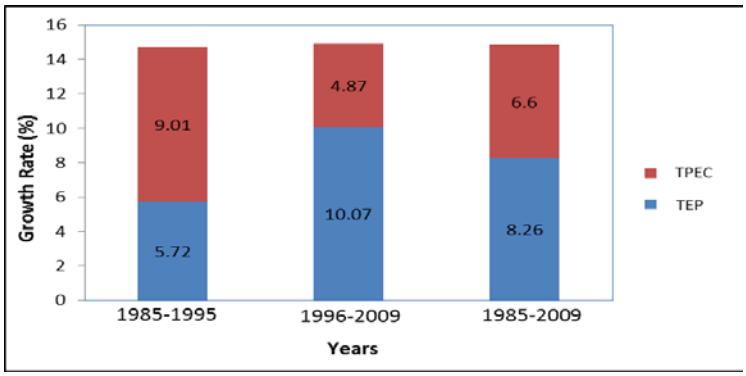


Fig. 4 Growth rate of total energy production (TEP) and total primary energconsumption (TPEC) in Qatar from 1985 till 2009 at different time periods

4) Per Capita Consumption

The highest growth rate of per capita energy consumption (PCEC) was found for the period 1991-1995 (7.2%). The growth rate was slower for the period 1985-1990 (0.4%) and was decreasing for the periods 1996-2000 (-1.6%), 2001-2005 (-0.8%) and 2006-2009 (-9.8%). A negative growth rate means that the energy consumption per capita is decreasing on average between 1997 and 2009 as shown in Fig. 5. Although the energy consumption in the country is increasing with time, we notice that the energy consumption per capita and the growth rate are following a decreasing trend which is mainly attributed to the rapid increase of the population growth rate. As shown in Fig. 5, the growth rate of the population and per capita consumption follow opposite trends and for the highest population growth rate, the PCC growth rate is the lowest. When we analyse the population growth trend (Table 2), we see that the population has been increasing since 1996. The highest growth rate is calculated for the period 2006-2009 (16.4%) followed by 2005-2006(7.6%), 1985-1990 (6.8%), 2000-2005 (4.5%) and 1991-1995 (3.2%). Overall, the highest growth rate of the population is recorded for the period 2001-2009 (9.04%) compared to a slower growth between 1985 and 2000 (5.03%). A major part of the population growth consists of the increase in the size of non-national labours due to the high rate of migration. For instance, the number of non-qatari labours working in the industrial sector increased by 188% between 2001 and 2007 [31]. In addition, the proportion of foreign population increased rapidly and reached more than 81% between 2006 and 2009 [32]. Consequently, such increase in the number of workers didn't affect the per capita energy consumption in the same way due to the fact that this category of residents conduct a different lifestyle that does not include the use of vehicles, electric appliances, air conditioning systems, etc. which lead to less energy consumption as compared to the rest of the population.

The GDP is increasing from 1985 till 2009 as given in Table 2. The GDP has recorded a positive growth from 1985 to 2009. However, the growth rate was the highest for the period 2006-2009 (18.4%). The increase of GDP growth has a similar trend to the population growth and the highest growth corresponds to the period 1996-2009 (12.81%) compared to a lower rate calculated between 1985-1995 (6.06%) as illustrated in Table 2.

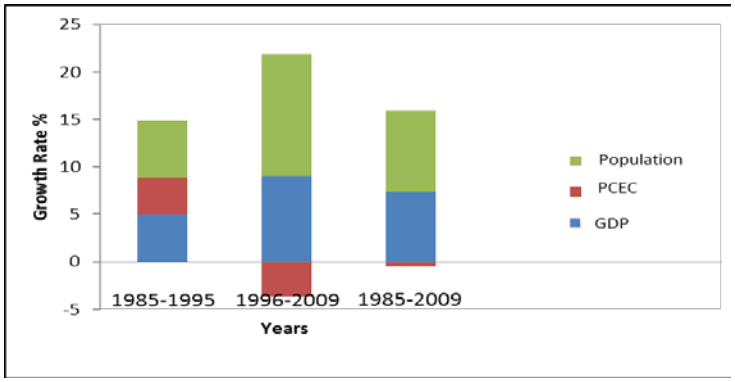


Fig. 5 Growth rate of Population, Per Capita Energy Consumption (PCEC) and GDP in Qatar from 1985 till 2009 at different time periods

Year	Population (millions)	Growth Rate (%)	PCC (MBtu)	Growth Rate (%)	GDP (QR)	Growth Rate (%)
1985	0.305		797.4		35871	
1991	0.436	6.8	811.6	0.4	43977	4.2
1996	0.510	3.2	1137.1	7.2	49338	2.4
2001	0.649	4.5	1044.9	-1.6	83886	11.6
2006	1.042	7.6	950.5	-0.8	124167	8.3
2009	1.631	16.4	628.1	-9.8	243492	18.4
	Population Growth Rate (%)		**PCC Growth Rate (%)**		**GDP Growth Rate (%)**	
85-95	5.03		3.79		6.06	
96-09	9.04		-3.67		12.81	
85-09	7.37		-0.56		8.59	

Table 2. Growth rate of population, PCC and GDP in Qatar (1985-2009)

III. MODELING APPROACH

In this part, the study proposes a statistical regression decision-tree model that in a simple, realistic and practical way predicts the variation of primary energy consumption, based on the analysis of anthropogenic and socio-economic parameters (predictors) likely to impact on energy consumption and quantification of their weights in a study area across Qatar.

A. Model Choice

The decision-tree model is a logical model (deductive reasoning) represented as a binary (two-way split) tree that shows how the value of a variable – named target variable (in our case primary energy consumption) – can be predicted by using the values of a set of predictor variables. It has a number of advantages when compared to numerically oriented techniques such as linear and nonlinear regression (function fitting), logistic regression, artificial neural networks ANNs, and genetic algorithms [33]-[35]. Decision-trees are easy to build and interpret, and can automatically handle interactions between both continuous (ordinal, interval) and categorical (nominal) variables. They do not require the specification of the form of a function to be fitted to the data as is necessary for other competing procedures (e.g., nonlinear regression). In addition, once a decision-tree model has been built, it can be converted to statements that are implemented easily in most computer languages without requiring a separate interpreter.

Moreover, decision-trees can identify a target (dependent) variable. This is not possible with unsupervised machine learning methods like cluster analysis, factor analysis (principal component analysis) and statistical measures [36],[37] which treat all variables equally without predicting the value of a variable.

B. Collection of Predictor Parameters of Energy Consumption

Primary energy consumption is driven by many social and economic factors such as the population growth and the GDP growth. It also depends on the industrial activity such as the primary energy production, the electricity production and consumption. For that, in the regression tree analysis, these

five parameters were selected as the independent variables, whereas the values of energy consumption were dependent variables. The generated parameters for Qatar, i.e. population, GDP, electricity generation, electricity consumption, primary energy production were provided from U.S. Energy Information Administration and Qatar Statistics Authority. The rules of quantifying/understanding of the impact of these parameters on primary energy consumption could be acquired from the training data through the built regression-tree model.

C. Regression-Tree Analysis of Energy Consumption

An ASCII point data file for the sample locations was constructed. This file comprises several columns: the primary energy consumption (target variable) in Quadrillion Btu (QBtu), and various continuous predictor parameters (population, GDP, electricity generation, electricity consumption, primary energy production). A decision-tree model was explored using this file with several steps: (1) find the best possible split through the examination of each predictor, (2) create two child nodes, (3) determine into which child node each field location goes, and (4) continue the process until the criterion of the minimum node size is fulfilled.

Once the regression tree has been developed, it encodes a set of decision rules that define the range of conditions (values or classes of predictor variables) best able to predict the primary energy consumption. The process is recursive, growing from the root node (the complete data set) to the terminal nodes in a dendritic fashion [38], [39]. Splits or rules defining how to partition the data are selected based on information statistics that measure how well the split decreases impurity (heterogeneity or variance) within the resulting subsets [40], [41]. We considered differences in the value of a continuous parameter up to 1% of the whole range, which is equivalent to 10,000 classes [42].

The Gini method was applied as the impurity measurement technique for evaluating the quality of the constructed trees [38], [41], [43]. It measures the degree of inequality of a variable in terms of frequency distribution and ranges between 0 (perfect equality) and 1 (perfect inequality). The Gini method, considered as the default method, is slightly better than the Entropy tree – fitting algorithm [42]. The Gini mean difference (GMD) is defined as the mean of the difference between each observation and every other observation (Eq. 1) [38]:

$$GMD = \frac{1}{n^2} \sum_{j=1}^{n} \sum_{K=1}^{n} \left\{ \left| X_j - X_K \right| \right\} \qquad (1)$$

Where X is the cumulative percentage (or fractions) and their respective values (j and k) and n is the number of sampling observations (in our case n =31).

D. Accuracy Assessment of the Constructed Regression-Tree

The maximum tree elevation was not specified in this study, as was the case for earlier programs such as AID (Automatic Interaction Detection) [44]. A tree that is too large needs to be pruned back to its optimal size (i.e., backward pruning) on the basis of a V-fold cross-validation [45] with several assumptions such as random-row-holdback validation, fixed number of terminal nodes and smooth minimum spikes. A V-fold cross-validation was used because of its accuracy in past studies [13], [38] and because it does not require a separate independent dataset that would reduce the data available to build the energy consumption regression-tree. A V-fold (or partition) value of 10 was adopted in this study, since a larger value increases computation time and rarely results in more optimal trees [46]. In 10 V-fold mode, the entire dataset (31 rows) is divided into 10 equal subsets; once the 10 partitions are

created, the rows of the ASCII table are collected in 9 of the partitions into a new pseudo-learning dataset. A test tree is built using this pseudo-learning dataset. The quality of the test tree for fitting the full learning dataset will, in general, be inferior to the reference tree because only 90% of the data was used to build it. Since the 10% (1 out of 10 partitions) of the data that was held back from the test tree built is independent of the test tree, it can be used as an independent test sample for the test tree. The 10% of the data held back when the test tree was built, is run through the test tree and the classification error for the data is computed. This error value is stored as the independent test error value for the first test tree. A different set of 9 partitions is now collected into a new pseudo-learning dataset. The partition being held back this time is selected so that it is different from the partition held back for the first test tree. A second test tree is built and its misclassification error is computed using the data that was held back when it was built. This process is repeated 10 times, building 10 separate test trees. In each case, 90% of the data is used to build a test tree and 10% is held back for independent testing. A different 10% is held back for each test tree. Once the ten test trees have been built, their resubstitution error (RE) rate (known as cross validation cost) as a function of tree size is averaged. The tree size that produces the minimum cross validation cost (error) corresponds to the optimal pruned tree size that shall be considered to be good enough for predicting future values as the larger (reference) un-pruned trees. The resubstitution error (RE) is considered as the estimate of error based on the differences between the predicted energy consumption of the built tree-model and the observed indicator in the dataset; the variance explained by the tree-model can be approximately expressed by (1 – RE) multiplied by 100% [45]. The variance (V in %) is one of several descriptors of a probability distribution, describing how far the energy consumption lies from the mean (expected values) [42].

E. Tree Model Performance

The regression-tree model created with 13 nodes (Fig. 6) correctly classified 95% of the training data, but V-fold cross validation indicated that this model would correctly classify 80% of an independent dataset. The mean value of the target variable (i.e. primacy energy consumption in QBtu) of the rows that are in a terminal node of the tree is the estimated median value. From the tree (Fig.6), one can see that if the primary energy production is equal or less than 3.2, then the estimated (average) value of the target variable is 0.415, whereas if the primary energy production exceeds 3.2, then the average value of the target variable is 0.9229. The number of observations (N) per node ranges from 3 to 24.

The minimum validation relative error (or validation cost) occurs with seven nodes, at a value of 0.24 and a validation standard error of 0.12. This validation error value is the cost relative to the cost for a tree with one node. It is the best measure of how well the tree will fit an independent dataset different from the learning dataset.

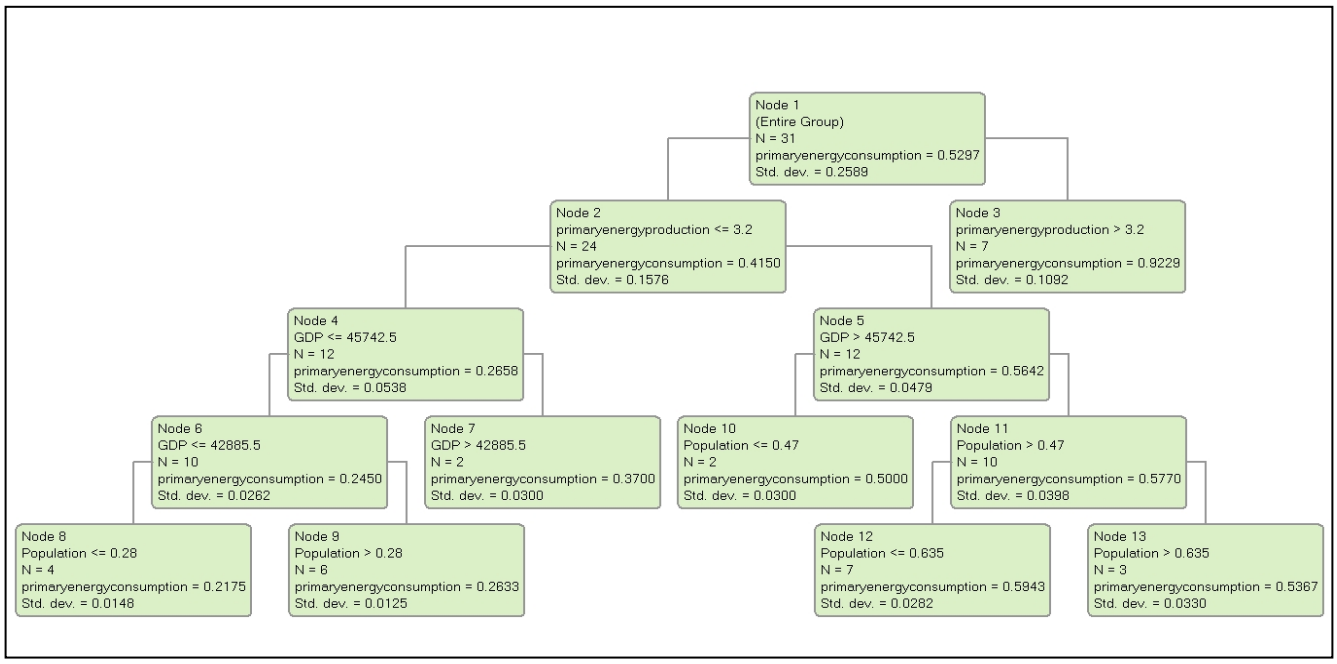


Fig. 6 Regression-Tree model created with 13 nodes

F. Evaluation of the Influence of Independent Parameters on Energy Consumption

The relative importance of the predictor parameters is represented as follows: primary energy production (100% in relative importance), GDP (40%), and population (25%). The primary energy production appears as the master parameter (generating the split from the parent node) in the whole energy process, since it is strongly correlated with the energy consumption. In fact, this result confirms previous observations in figures 1 and 2 where it has been shown that the higher part of the primary energy consumption goes to the energy industry own use and petrochemical feedstock to start a new cycle of the energy production. In addition, there is a good correspondence between GDP and energy consumption which is explained by the fact that a country with high GDP can undergo a fast development at the construction and services level leading to higher energy consumption. Population has demonstrated a certain impact by influencing the primary energy consumption since a huge amount of energy is consumed in order to provide the growing society with the needed supplies and services. The other parameters (i.e. electricity consumption and electricity generation) do not intervene in building the regression-tree, and their effect is totally masked.

G. Advantages and Limitations of the Constructed Energy Model

Our regression-tree model (95% variance) performed significantly the prediction of energy consumption and appeared useful for integrating and determining the exact weights of a wide variety of predictor parameters (both anthropogenic and socio-economic). This decision-tree model can meet the scientific needs of researchers and decision-makers for exploring different scenarios and can also be tested for the secondary energy consumption in Qatar (i.e. electricity) and for the CO2 emissions as well, if their predictor parameters are known and measured.

The analysis of the explained variance for the built regression tree-model suggests its possible improvement using other parameters yielding a finer detail and subtle relationships in energy consumption such as the number of residential units, the impact of the growing number of expatriates, the average income and expenditure per capita, etc.

IV. CONCLUSION

This study showed that the growth rates of energy production and consumption in Qatar have been variable over the years. The increase of energy consumption does not follow the same trend as that of the population due to the large immigration of labours who, according to their lifestyle, are less consumers of energy than the rest of the population. The decision-tree model confirmed that energy consumption in Qatar is mainly influenced by the energy production sector and that the increase of consumption depends 40% and 25% on GDP and population respectively.

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