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A green process for extraction of omega 3 fish oil from tuna byproducts

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Abstract

Fish industry discarded a great amount of fish byproducts as processing left over every year. Proper utilization of these byproducts could increases the overall value of the catch and decreases environmental pollution. Tuna fishes are mainly traded as canned or frozen food product. During canning process of tuna fish, a large amount (~60% of total weight) of solid wastes were generated as by-products which contain omega 3 fish oil that is beneficial for human health. Conventional solvent extractions are generally employed to obtain fish oil; while often introduces contaminants that must be removed later. Supercritical carbon dioxide (SC-CO_2) extraction is regarded as green process which offers a new opportunity for the solution of separation problem as it is nontoxic, environmental-friendly, residue-free and one step method. The objective of this study was to identify an extraction technique using SC-CO_2 to recover the maximum oil yield from tuna fish byproducts using the minimum amount of CO_2.

The extraction were performed at temperature 45 to 65 ^{0}C, pressure 20 to 40 MPa and flow rate 2 to 4 ml min^{-1}, where 65 ^{0}C/40 MPa/4 ml min^{-1} gave the highest yield of 20.6, 35.5, and 30.8 g/ 100 g sample (dry basis) for the continuous, cosolvent, and soaking techniques of SC-CO_2, respectively. The yields were closer to the yield of conventional Soxhlet (36.2%) method. The results indicated that, oil yield increased with pressure and temperature. The poor extractability by continuous extraction technique may be due to mass transfer limitations within the solid matrix. The enhanced extractability by cosolvent extraction can be attributed to enhanced solvent power. Docosahexaenoic acid (DHA) was characteristically the major omega 3 fish oil accounting for 17.01-19.90% in head, 15.73-17.290% in skin and 14.31-16.06% in viscera of total fatty acids. The highest CO_2 consumption was found in continuous technique (943.5 g), followed by soaking (471.7 g), and co-solvent technique (258.6 g) respectively. On the whole, it was observed that co-solvent method of SC-CO_2 is an effective method to extract fish oil that is rich in omega-3 fish oil from tuna byproducts.

Keywords: Tuna by-products; omega 3 fish oil; Supercritical extraction; Cosolvent technique; CO_2 consumption

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A Systematic Review of Ecological Footprint (EF), Biocapacity (BC) and Population Trends: A Study of Myanmar

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Abstract

In 2007, the global Ecological Footprint (EF) was 18.2 billion gha (2.7 gha per person), whereas, the Earth's total Biocapacity (BC) was 12.0 billion gha (1.8 gha per person). Humanity has only one planet to support their consumption and demand. Today, global population uses the equivalent of 1.5 planets to provide the resources they use and absorb their waste. The Ecological Footprint is a concept to estimate the land area needed to support the human consumption such as food, housing, energy and their waste assimilation. The consumption of natural resources, and the generation of wastes demands natural resources as source and sink, which are increasing year after year. Depend on regions and countries; Ecological Footprint varies among each country according to individual lifestyle, consumption rate, and population density, etc. According to the Ecological Footprint and Biocapacity trends, nations are classified in either Ecological Creditors or Ecological Debtors. If the Ecological Footprint shows that more natural resources are used than the Earth supplies, this is not a sustainable lifestyle. This paper analyses and reviews the trends of EF, BC and population of Myanmar by synthesizing existing data from various reports. Myanmar statistics shows that all of the variables—EF, BC, and population—are increasing at the accelerating rate. With the recent economic policy reform toward market economy after 1988, sustainable economic development together with maintaining the rich of its natural resources and building healthy society is still a challenging task for the government.

Key words : Ecological Footprint (EF), Biocapacity (BC), Carrying Capacity, Sustainable Development Planning

1. Introduction

1.1 Background Information

1.1.1 Geographic Information and the Land Use information

Republic of the Union of Myanmar is located in Southeast Asia and the total area is 677,000 square kilometers (land 653,508 sq km & water 23,070 sq km). It is rich in natural resources such as land, forests, precious minerals, and biodiversity and water resources which provide significant economic potential. It has a total coastline of 2,229 kilometers and shares border with five countries, two of which are the most populated nation—Indian on the North-West, China on the North-East, Bangladesh on the West, Laos on the East and Thailand on the South-East (over 40% of world population). According to the land use map acquired from 1991 National Forest Management and Inventory results, there is 44 percent of combined evergreen, deciduous and mangrove forested area, 54.3 percent of combine agricultural and scrubland and 0.2 percent of water bodies and 1.7 percent are no data available. The national statistics have shown that the forest area is decreasing from 60.2 percent in 1995 to 48.62 percent in 2010.

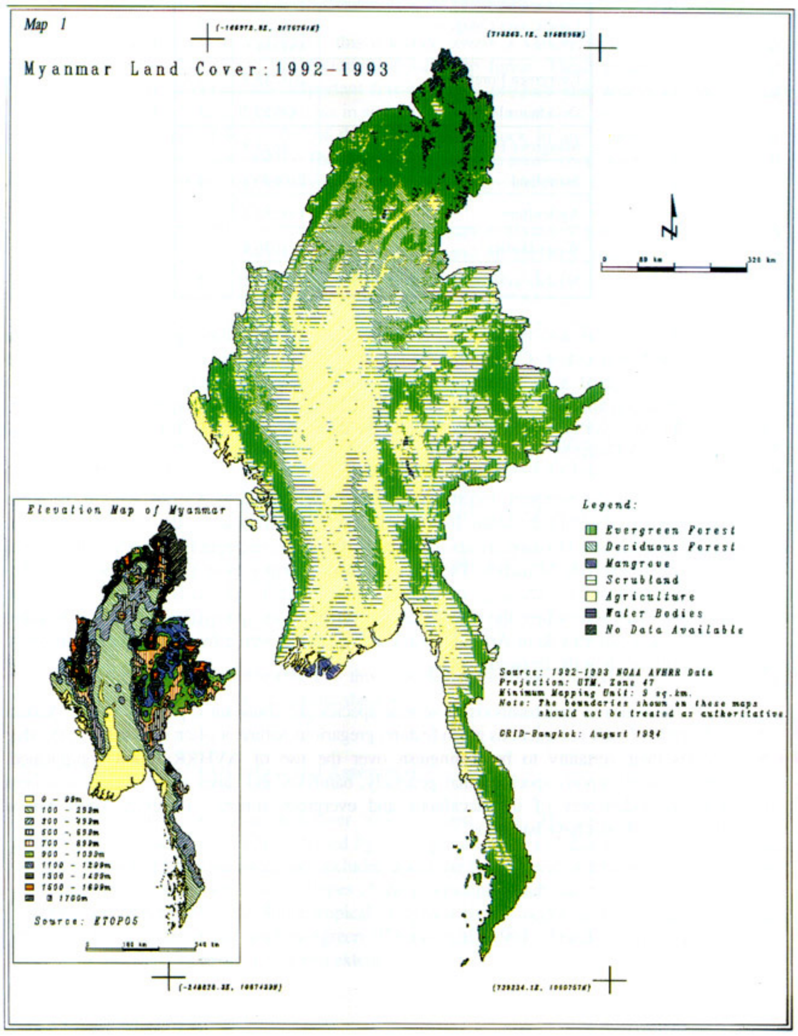


Figure 1: Myanmar Land Cover (1992-1993)

Geographically, Myanmar has the main three parallel chains of forest clad mountains as the Western Yoma or Rakhine Yoma, the Bago Yoma and the Shan Plateau. The three mountain chains divide the country into three river systems such as the Ayeyarwady, Sittaung and the Thanlwin.(National Sustainable Development Strategy for Myanmar)

1.1.2 Demographic Information

In term of the demography, the current population is 63 million with the population growth around 2.01 % per year. The population is expected to reach 100 million in the year of 2035 .The population density is 80.60 per square kilometers in 2012. The total fertility rate is 2.23. Most of Myanmar's people lives in rural areas and their livelihoods are mostly depend on agriculture.

1.1.3 Social information

When looking at other indicator, social indicators, despite the increase of standard of living, many other reports found that the quality of life and the happiness of the people have decreased overtime.

Happiness
Crime
Time

Social Breakdown

Impact of globalization i.e. "Myanmar, at the present moment is still maintaining its culture, that is, to obey and respect the elders, to have respect for each other, and to show kindness to young ones. This norm still prevails and incidences such as young people attacking the elderly, the student attacking the teacher are quite unheard of. However with the advancement of information and communication technology and the impact of globalization, influence of other cultures, especially Western culture, can be seen in the young generation. They try to adopt the behavior of the West, especially in their attire. Thus there is a need to instill in the younger generation a keen desire to value one's culture both tangible and intangible, and to preserve and safeguard it." (National Sustainable Development Strategy for Myanmar, pg 75-76) .There are many famous places of the historical, ancient and cultural interests in Myanmar. Myanmar temple architecture is mainly constructed with brick and stucco and pagodas are covered with layers of gold leaf. Monasteries are mostly constructed with wood. Therefore, the preservation and reconstruction of ancient cities and ancient places are very important. To maintain the traditional culture, it should improve the traditional cultural art and architecture, traditional sports and traditional dresses show competitions annually. Social awareness is very important to protect and preserve the Myanmar cultural heritage and properties. Therefore, it is needed to promulgate and award giving by using media such as television, radio and internet. In Myanmar, Protected areas (PAs) are important for biodiversity conservation and sustainable development. PAs protect the ecosystem and services such as carbon sequestration and climate regulation, water provision, food production, thus improving people's livelihoods. PAs keep the integrity of spiritual and cultural values placed by indigenous people on wild areas. It gives the opportunities of inspiration, study and recreation. Myanmar has about 43 officially recongized PAs.

Sustainable Development Indicator Table

Sustainable Development Indicator					
General	**1995**	**2000**	**2005**	**2010**	**2012**
Population, total (millions)	44.74	50.13	55.39	61.19	63.67
Population growth (%)	1.85	2.04	2.01%	2.01	2.01
Total Land area(sq.kms)(thousands)	653.54	653.54	653.36	653.29	-
Environment					
Forest area (% of area)	60.2	53.4	-	48.62	-
Nationally protected areas (% of total land area)	-	-	-	-	-
Annual deforestation (% of change)	-	1.39	-	-	-
Agricultural Land (% of Land area)	16	16.5	17.2	19.2	-
CO2 emissions (mt per capita)	0.17	0.2	0.31	-	0.23
Freshwater used (% of total water resources)	-	-	-	-	-
Ecological Footprint (global hectares per capita)	0.925	1.07	0.9	2.04	2.22
Social					
Human Development Index	0.346	0.382	0.435	0.490	0.498
Life expectancy at birth (years)	-	54.91	60.7	64.52	65.24
Adult literacy rate(over 15 years)	-	89.89	-	-	-
Urban population (% of total)	26	27	29	32	-
Improved water source (% pop with access)	-	71	-	78	-
Economic					

GDP (current US $)(billions)	-	1,500	1,700	1,400	-
Real GDP growth (%)	-	4.9	5.2	5.3	-
GNI (US$ billions)	-	-	-	-	-
Population below poverty line (%)	-	25	-	-	-
Electric power consumption per capita (kwh per capita)	60	78	79	131	-

Contrasting Photos between Traditional Life and Modern Life

Traditional Life Photos




Modern Life Photos



1.2 Review of Carrying Capacity Concept

The carrying capacity concept was pioneered by Thomas Malthus in the year 1798. Thomas Malthus theory argues that population growth will eventfully effect on food supply. In his theory, the population rate is growing as geometric rate and the food production is increased as arithmetic rate. Population will exceed the carrying capacity of natural resources. He distinguishes two categories as preventive checks and positive checks to limit the further population growth. The preventive check is population growth limited by voluntarily such as fertility rate reduction of individual family planning. The positive check is increased death rate by famines, wars and diseases to reduce the population size. The carrying capacity was adopted for wildlife management, chemistry, medicine, economics, engineering and population biology, etc.In 1870, carrying capacity was practically used for living organisms and natural systems. It is also used as a model to determine the amount of animals in a given area. In this situation, carrying capacity is the number of animals which can be sustained in a given area without starting to destroy the environment. In 1887, Botanical Gazette said the carrying capacity for the pollen of specific flowers. Leopold studied the different population dynamics in different species. He informed the generations of wildlife managers about carrying capacity. They are often used to support neo-Malthusian arguments.

In "An Essay on the Principle of Population", he predicted that sooners or later ecological overshoot will occurs since the earth can only hold a definite amount of human growth for a definite time. This concept holds a crucial position in determining the quality and state of an ecosystem with respect to the pressures required by the demands of the dwelling population. It is basically an ecological concept that also embraces the socio-economic parameters. In simple terms, the carrying capacity of an area can be defined as the maximum number of people that can be supported by the environment of that area through optimum utilization of the available resources. Therefore, if the population growth is exponentially increased, earth itself is not growing and thus people would eventually run out of food and space. Our planet and its natural resources are limited and so it cannot expand as our population expands. Nowadays; the carrying capacity is the important concept for environment politics. For human and environment interaction, carrying capacity concept can be used. It can also be used to support neo-Malthusian arguments regarding that the relation between the world's resources and increasing human population densities.

1.3 Broading the concept of Carrying Capacity: A review of Paul R. Ehrlich (I=PAT)

Despite the widely popularized concept in environmental studies, the human carrying capacity is a contested theory subjecting to the debate. For example, Julian Simon believed that carrying capacity is unlimited due to human creativity. Moreover, he claims that the population growth can cause temporary negative effect on living standards. However, population growth could have the positive effects on living standards due to the advance in knowledge and economies of scale. Empirical study has shown that the living standard has increased in both developed and less developed countries with moderate population growth. In a long run, the growing of population will lead to evolving of new knowledge, higher technology and increased production rate to support the higher demand.

However, it more prudent to the country to stilling for moderate population growth and stressed importance of fertility decision making by parents. These two criticisms are developed after the three observations. The first factor is the comparison of population growth rate and the stages of development between low-income and high-income countries. The population growth rate of low-income countries is 2% and high-income countries are usually less than 1% at the same period (1965-1990).The second factor is the negative correlation between the fertility rates and income per capita. Low fertility rate usually lead to higher income per capita. Third factor is the life Expectancy at birth. People are usually live longer for high income countries due to the medical advancement. According to this process, when the fertility rates are permanently lower, the standards of living will improve. However, Paul Ehrlich (the author of ‘The Population Bomb) believed otherwise. He proclaimed that the carrying capacity of the earth would be rapidly exceeded despite the reduction of population number. Later, he developed the equation to describe the impact of human activity on the environment in the more details as following

$$I=PAT$$

Where, I = Human Impact on the environment, P=Population, A=Affluence (consumption) and T=Technology

According to the population increasing year after year, increasing the use of land, resource and also increased pollution. More population, more consumption and each product consumed a lot of natural resources and also created the pollution. However, People and each country could opt for new technologies that minimize impacts to the environment. Moreover, people could change their life style in a more sustainable way i.e. using public transportation rather than individual private cars.

1.4 World Human Population Growth

The human population continues to grow rapidly due to many factors such as education, health, poverty, place of residence, and social class. Population growth is the change in a population over time, and can be quantified as the change in the number of individuals of any species in a population using "per unit time" for measurement. The exponential growth of human population is influenced by birth rates, death rates, current population, average lifespan and population limit. The population is increase because birth rate is increase than death rate. At this condition, population is positive feedback. It has the exponential behavior. It is rapid exponential growth. These people consume vast amounts of food, water, raw materials, and energy and in the process produce huge amounts of pollution and wastes. The exponential growths of human activities are burning fossil fuels (carbon-based fuels such as coal, natural gas, and gasoline) and clearing forests .This could ruin some areas for farming, shift water supplies, and disrupt economies in various parts of the world. Therefore, it is need to approach steady state and maintain the population growing. The fact is, humanity today represents something unprecedented in the history of the world: never before has one species had such a great impact on the environment in such a short time and continued to increase at such a rapid rate.

In 1950s, the population of the world is less than 3 billion and global population increases above 1.8% per year. The human population has mostly grown exponentially over time. It has not actually maintained a constant percentage increase indefinitely, but during the mid-20th century the growth rate peaked at 2.1% per year and now is at about 1.4% today. The global population expected to reach between 7.5 and 10.5 billion by 2050 .As the world human population growing, threatening the food security, the outbreak of a new disease or a new strain of a previously controlled disease, pollutants: such as toxic metals, entering waters and fisheries, disruption in the supply of non-renewable resources and energy, soil erosion, a decline in groundwater supplies, and climate change will occur. Therefore, people awareness and sustainable management on environmental issue is very important and it is also needed to reduce the consumption level, population growth rate and manage the natural resources that sustain human population infinitely.

2. Review of Methodology

2.1 Ecological Footprint and Biocapacity

Ecological Footprint (EF): The Ecological Footprint (EF) is a measurement the amount of humanity's demand on natural resources. In the other words, EF is the measurement of the quantity of human consumption and the resources used (how much land area needed per person, city, country and world). It is usually expressed in the land unit as global hectares (gha). Ecological Footprint includes six components (cropland, grazing land, forest land, carbon footprint, fishing grounds, and built-up land).Among these components, carbon footprint are the most significant which has increased overtime due to deforestation, industrialization and urbanization, etc.

According to the National Footprint Accounts, in 1961, the demand of human population was 0.7 planets. However, in 2008 the consumption rate of human population on natural resources was 1.5 planets. The provision capacity of resources and ecosystem services are one of the most important roles for both economic benefit and social well-being. Ecosystem services contribute and strongly connect to human well-being in various ways. For example, high quality and stable flows of ecosystem services will affect the state of happiness, good health and prosperity of individual (MA 2005). In the contrast to the qualitative measure, National Footprint Accounts is less subjective measuring the amount of human demand and supply of resources as one main aspect of sustainability.

Biocapacity (BC): The Biocapacity (BC) is more looking at the supply side of natural resources. The concept attempt to calculate the capacity of Earth's ecosystem to produce the materials for the human consumption and to absorb the waste materials produced by humans.

If the Ecological Footprint (EF) exceeds the biocapacity (BC), biocapacity deficit or ecological overshoot will occur. When the biocapacity of a region exceeds its population's Footprint, a biocapacity surplus occurs.

2.2 Calculation of Ecological Footprint and Bioacapacity

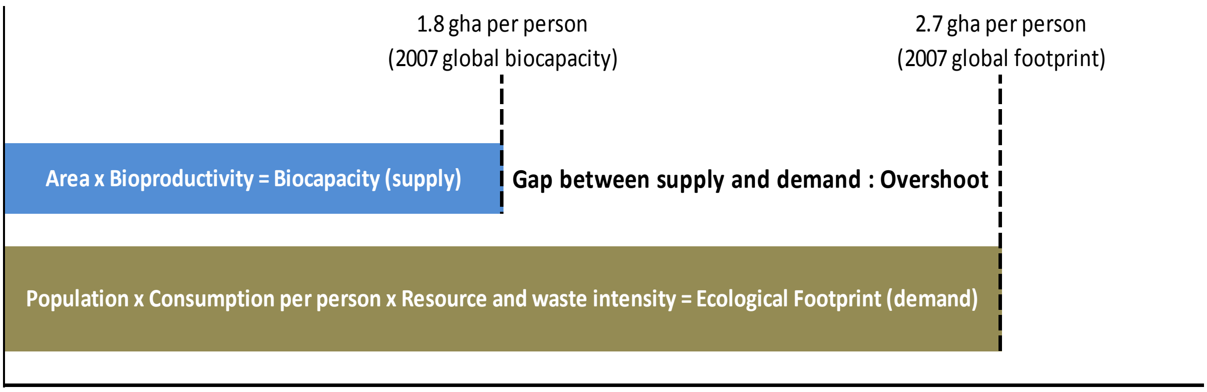


Figure 2: Ecological Overshoot

In this figure, the global Ecological Footprint is 2.7 gha per person and the supply is 1.8 gha per person. Therefore the rate of consumptions by human (demand) has exceeded the ecosystem services (supply) from the earth, Ecological Overshoot occur. The gap between the supply and demand called the Ecological Overshoot. Additionally, the natural resources would be depleted if the humanity's demand on Earth's ecosystem increased. To reduce the ecological deflect or global overshoot, women access to better education, economic opportunities and family planning, etc to reduce the population growth rate, to change the individual lifestyle to approach green, greener to greenest lifestyle, production and consumption, less non-renewable resources used in manufacturing processes, good land management and preserving the biocapcity such as protecting soil erosion, maintaining healthy forest and fisheries and preventing or minimizing the impacts of climate change to help the yields maintaining,etc.

Calculation of Ecological Footprint

$$EF=\frac{D_{ANNUAL}}{Y_{ANNUAL}}$$

Where; EF= Ecological Footprint;
D = Annual demand of a product;
Y= Annual yield of the same product (global hectares, gha) (Monfreda et al., 2004; Galli et al., 2007)

Primary demand for biocapacity, Ecological Footprint of production EF_p(**for a nation and land use type**) can be calculated as follows;

$$EF_p= \sum_i \frac{P_i}{Y_{N,i}} * YF_{N,i} * EQF_i$$

Where P = the amount of each primary product i (harvested or waste emitted, equal to D),
$Y_{N,i}$ = the annual national average yield for production i, and
$YF_{N,i}$=the specific yield factor for the production of each product i, and

EQF_i = the equivalence factor for the land use type producing products i

Major Land Used Type in Ecological Footprint

- Carbon -Calculated as the amount of forest land required to absorb CO_2 emissions from burning fossil fuel, land use change, etc.
- Grazing Land –Calculated from the area used to raise livestock for meat, dairy, hide and wood products. Grazing land include all grasslands used to provide feed for livestock.
- Forest Land-Calculated from the amount of lumber, pulp, timber products and fuel wood consumed by a country each year.
- Fishing ground-Calculated from the estimated primary production required to support the fish and seafood caught, based on catch data for 1439 different marine species and more than 268 freshwater species.
- Crop Land –Calculated from the area used to produce food and fiber for human consumption, feed for livestock, oil crops, rubber, import and export of primary and derived agricultural products.
- Built-Up Land-Calculated by the area of land covered by human infrastructure, including transportation, housing, industrial structure and reservoirs for hydropower.

Calculation of Biocapacity (BC)

Biocapacity measures the ability of available terrestrial and aquatic areas to provide ecological resources and services. A country's biocapacity for any land use type can be calculated as;

$BC=A_{N,i}*YF_{N,i}*EQF_i$

Where

BC = Biocapacity,

$A_{N,i}$ = the available productive area for the production of each product i,

$YF_{N,i}$= the country-specific yield factor for the land producing products, i

EQF_i =the equivalence factor for the land use type producing each product, i

3. Review of World Ecological Footprint, Biocapicity, Population and Sustainable Development Principles

3.1 Global Ecological Footprint and Biocapacity

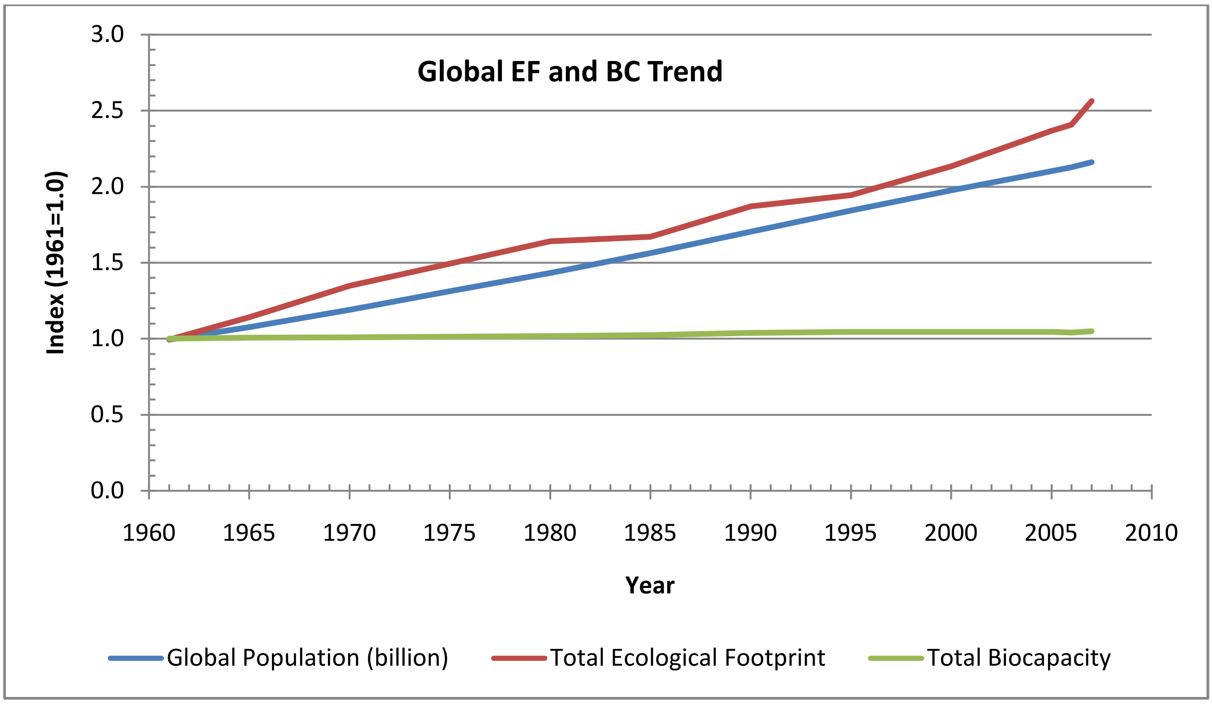


Figure 3: Ecological Footprint and Biocapacity

The graph is comparison between the global ecological footprint (EF) and Biocapacity (BC). It provide figures from 1960 to 2010 and it shows that the amount of ecological footprint and biocapacity (gha per capita). At the start of 1960, the amount of ecological footprint was 2.3 gha per person and it was steadily increased**.** Between 1970 and 1980, EF was increased significantly as 2.8 gha per person. About nearly 2002, EF was decreased a little as 2.5 gha per person**.** Between 1960 and 2007, biocapacity (BC) steadily (linearly) decreased. By the end of 2007, the amount of biocapacity was decreased just 1.8 gha per capita. The rates of consumption per person have been increasing and the earth's productive efficiency has been decreasing.

3.2 Effect of Carbon footprint on EF

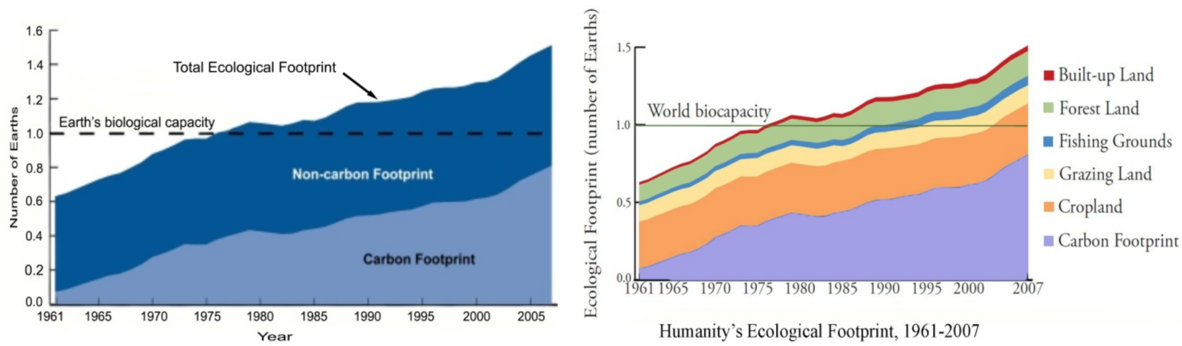


Figure 4: Ecological Footprint and Carbon Footprint

There are six components of ecological footprint such as built-up land, forest land, fishing grounds, grazing land, cropland and carbon footprint. According to the above figure data, the amount of carbon footprint is half of total ecological footprint. The most significant factor for growing EF is population growth and increase of consumption rate per person. According to the analysis of components of EF. Carbon is the highest among the components of EF. Carbon footprint can also affect on EF and ecosystem services.

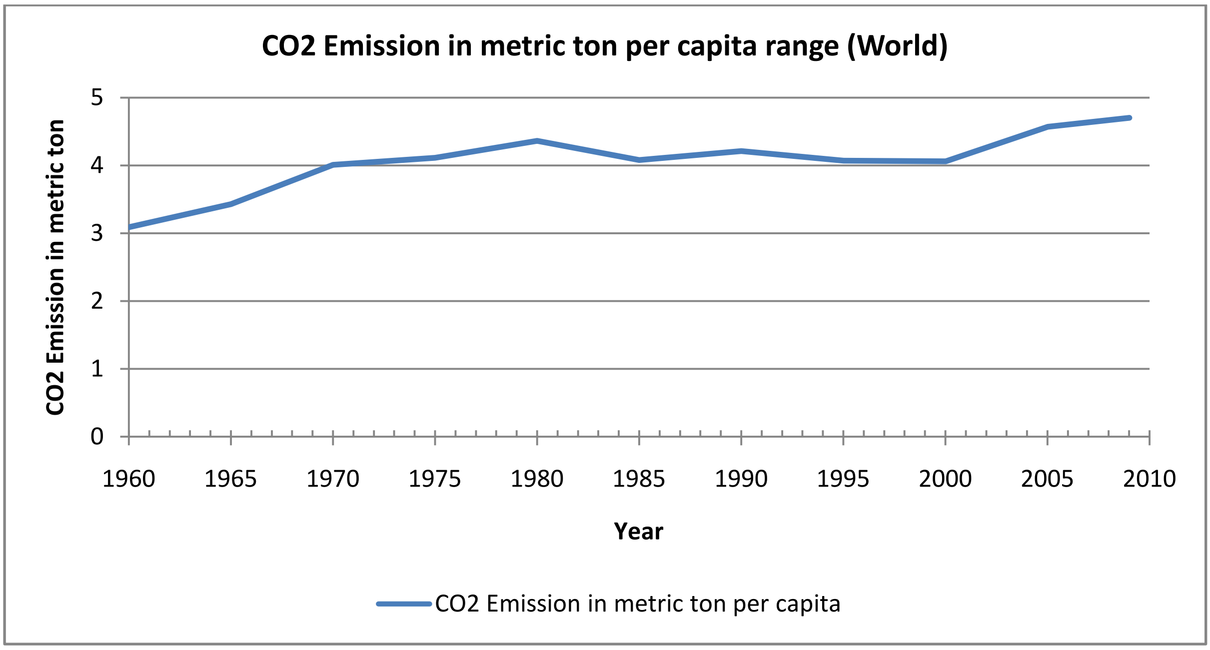
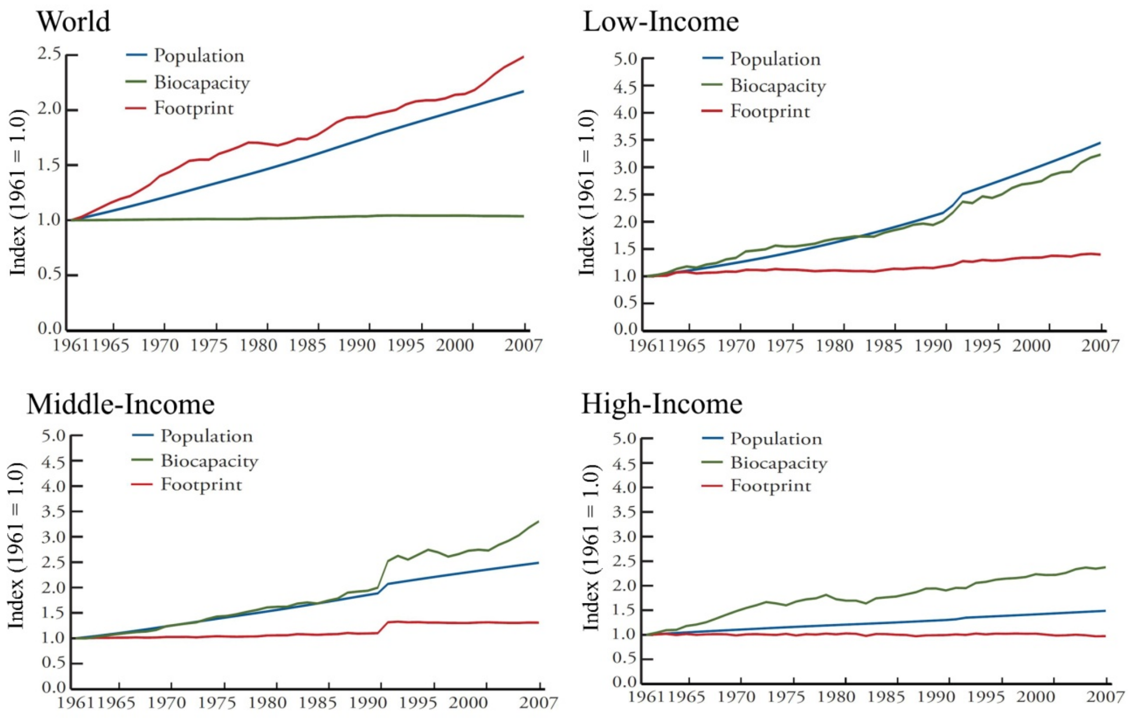


Figure 5: CO_2 Emission of World

The global mean temperature is increased from year to year due to the greenhouse gas increased. The greenhouse gas is especially CO2 .Carbon dioxide is breathed out or otherwise given off by living organisms (including plants) as they undergo aerobic respiration, and is taken in by green plants during photosynthesis. The population growth is the main drivers of increases in greenhouse gas emissions .The primary way we are increasing the CO2 content of the atmosphere is through the burning of fossil fuels, coal, oil and gas. The people of the industrialized countries disproportionately produce carbon emissions from the burning of fossil fuels. The climate change such as global warming caused by increasing the concentrations of greenhouse gases produced by human activities.

Due to the human activities such as burning of fossil fuels and deforestation, carbon dioxide level is increased and become global warming. The greenhouse gas emission also increased by deforestation**.** The plants and trees can absorb the greenhouse gas such as carbon dioxide. Trees are important role in the carbon cycle and it converts carbon dioxide to oxygen into the air. The demand of tree-based products, land, fuel and land are increased and so the problem of deforestation grew year after year. Forests absorb carbon dioxide and convert oxygen by photosynthesis process. People cut down trees for paper use and other purposes, deforestation occurred and the amount of carbon dioxide is rising. The effects of an increase in global temperature, a rise in sea level and also other effects such as extreme- weather events including heat waves, droughts and heavy rainfall, ocean acidification and extinctions can suffer. The increased mean global temperature can effect on human food security due to the decreasing crop yield and loss of habitat.

3.3 EF, BC and Population (For High-Income, Middle-Income and Low Income Countries, 1961-2007)



World, Low-income, Middle-income, and High-income Indexed to 1961

Figure 6: EF, BC and Population for Low-income, Middle-income, and High-income Countries

There are four graphs to show the world population, ecological footprint and biocapacity between 1961 and 2007.There are three income groups as high-income, middle-income and low-income countries. The global demand and supply of world, high-income, middle-income and low-income countries. The four graphs show the relationship between changes in population, three income levels, the consumption changes per capita and the efficiency of regenerative productive area. We can see the different trends of Ecological Footprint, population at a global level, three income group and availability of biocapacity. Population growth plays an important role for total ecological footprint. In conclusion, high-income countries, the number of population were not significantly increased, however ecological footprint was increased and biocapacity decreased depended on their income and their consumption rate. For the low-income countries, the population growth rate was increased and biocapacity was decreased. The ecological footprint was not increased because their income, depend on their lifestyle and consumption rate on earth’s ecosystem.

3.4 Sustainable Development Principles

Within the society , social development and political development is competitive and also related each other .From nature, human get benefit from ecosystem services .For social development, they used many natural resources from nature and for sustainable development , good policy is needed to protect the environmental degradation and for human well beings. Depending on the sustainable development among social, political and ecological sector has various conflict and relationship each other. For the sustainable development not only the government but also the socio-economic and political development must be shared by the civil society and the business respectively each other.

3.4.1 Ecological Principle

1. Ecological Soundness: For environmental sustainability, people should understand the value of ecosystem services and natural environment. Human get free benefit from ecosystem (natural environment).We get food, fuel, medicine from special plants and raw materials for products. Human well being is directly related with healthy ecosystem. Human beings are the center of concerns for sustainable development. Human need to recognize their nature as their common heritage and thus limiting the carrying capacity and integrity of nature in the development process to ensure the right of present and future generations to this heritage.
2. Living with the Carrying Capacity of the Environment. Our natural capital have limit to supply resources and absorb wastes from human activities. Some resources are renewable but take long time. Therefore, minimizing the amount of non-renewable energy is very important issue .For sustainable energy approach, we should try to get energy from solar, hydropower and wind turbine.
3. Understanding Ecological Dynamics: we should be considered about ecological dynamics. Ecological communities act as feedback loops, so that the community maintains a relatively steady state that also has continual fluctuations. The populations of the individual species rise and fall, but balance within the system allows them to thrive together. Humans have the capacity to restore the natural systems to greater health through effective planning, implementation and management. For a sustainable future, humans must effectively integrate with nature, not separate from it.

3.4.2 Political Principles

1. Cooperation: To achieve sustainable development and a higher quality of life for all people, states shall cooperate in a part of global partnership to conserve, protect and restore the integrity of Earth's ecosystem and maintain health problems. States should reduce and eliminate unsustainable patterns of consumption and production.
2. National Sovereignty: Self-determination at with national level where the norm of society and the specific of local ecology inform national governmenance. Include human and environmental society as well as achieving and ensuring security and self-reliance in basic stable foods. Nations should cooperate to promote an open international economic system that will lead to economic growth and sustainable development in all countries. Environmental policies should not be used as an unjustifiable means of restricting international trade.
3. Addressing the root causes. Every problems need to solve and find the causes of the problems. All over the world, including Myanmar have been facing many problems or natural disasters. Thus, people need to address the root causes of environmental degradation for sustainable development without disturbing the nature. Current pollution generated level from economic development is less however as we know 'prevention is better than curing'. To control the polluters which environmental degradation and pollution, policy instruments should be used. For control pollution, we have two approaches as property rights approach (The Coasian Solution) and government policies. Government policies have three methods. Three methods are Market Based Instruments (MBI), Command and Control (CAC) Instruments and

Other instruments. There are four types of MBI. First is a charge such as emission charges, user charges, product charges and administrative charges. Second is a subsidy third is marketable permits and final type is other MBIs. The other MBIs are deposit-refund schemes, ecolabelling, performance bonds and traditional property rights. Command and Control (CAC) instruments are ambient standard and emission standard. The emission standard has two types as performance- based standards and technology-based standards. The other instruments are voluntary incentive, liability legislation, education, zoning, fines and bans. The international law is adopted to provide the compensation for irreversible damage and to protect the environment. For sustainable development project also needed to enforce law and financial resources are needed for developing countries.

3.4.3 Social Principles

1. Social Justice- To promote and enhance environmental awareness, society is an important role. People awareness, knowledge, environmental education, education development in rural, health services improvement and human resource developments are mainly factors of sustainable development for developing countries. It is used to ensure social cohesion and harmony through equitable distribution of resources and providing the various sectors of society with equal access to development opportunities and benefits today and in future. The sustainable development is recognized as shared, collective and indivisible responsibilities which call for institutional structures that are built around the society, convergence and partnerships between and among the stakeholders.
2. Participatory- The participation of all sectors of society in development-decision making and processes and to operarionalize inter-sectoral and multi-sectoral census. To achieve sustainable development is needed to meet equity the environmental protection and development. Also need the freedom participation in decisions regarding the management and development of one’s home and neighborhood, with respect for civil and political rights and in the implementation of environmental legislation. Corporate Social Responsibility (CSR) is the decision-making and implementation process that guides all company activities in the protection and promotion of international human rights, labor and environmental standards and compliance with legal requirements within its operations and in its relations to the societies and communities where it operates.CSR involve a commitment to contribute to the economic, environmental, and social sustainability of communities through the on-going engagement of stakeholders, the active participation of communities impacted by company activities and the public reporting of company policies and performance in the economic, environmental and social arenas.
3. Gender Equity- For gender equity, recognizing the important and complementary role and empowerment of both men and women in development .The indigenous people and other local communities have a vital role in environmental management and development. Eradicating poverty and reducing disparities in living standards in different parts of the world are essential to achieve sustainable development and meet the needs of the majority of people.

4. Analysis and Discussion

4.1 Total Ecological Footprint, Biocapacity and Population Trends (Myanmar)

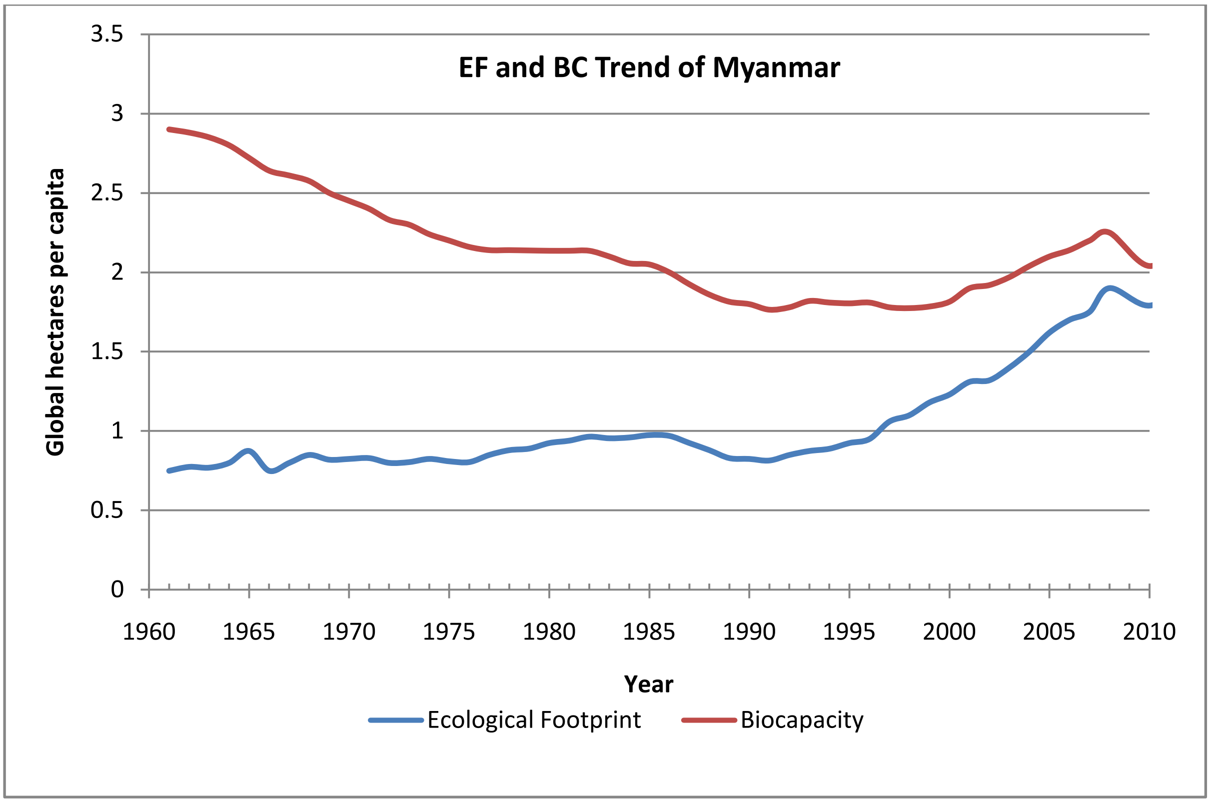


Figure 7: Ecological Footprint and Biocapacity Trend(Myanmar)

In 2010, the Ecological Footprint of Myanmar is 1.79 gha per person and Biocapacity is 2.04 gha per person. Compare to 2012, EF and BC of Myanmar is 1.94 gha and 2.22 respectively. Due to Myanmar's BC is greater than EF; Myanmar is a ecological creditor nation. Although currently Myanmar is a ecological creditor nation, EF is keep on increasing year by year and BC won't be effort to cover EF in nearly future. In the next 10 to 20 years, if Myanmar's consumption rate will increase, ecological footprint will exceed the regenerative bioproductive capacity of natural resources, ecological deficit can occur. With the increasing of population, industrialization, urbanization and globalization, Myanmar population will also more demand on natural resources for economic, social perspective, etc. If any nation consumes more than its own ultimate supply of ecosystem services, it become an ecological deficit.

4.2 Population, Population Growth Rate and Carbon dioxide Emission (Myanmar)

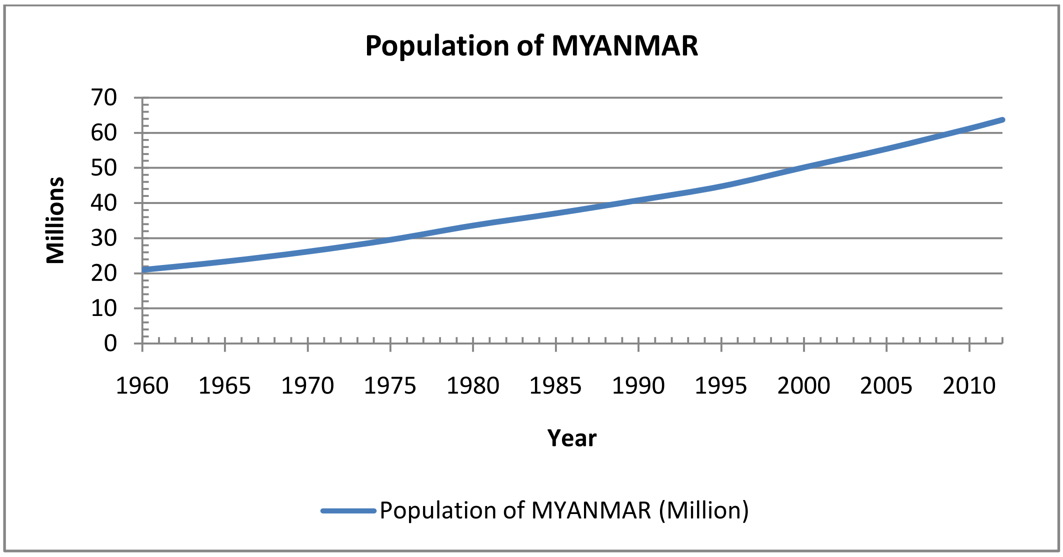


Figure 8: Population (Myanmar)

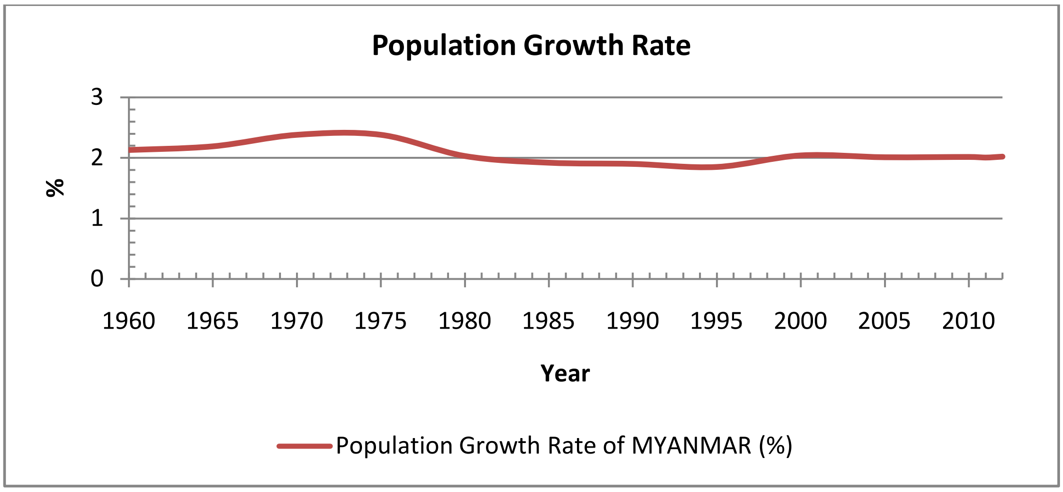


Figure 9: Population Growth Rate (Myanmar)

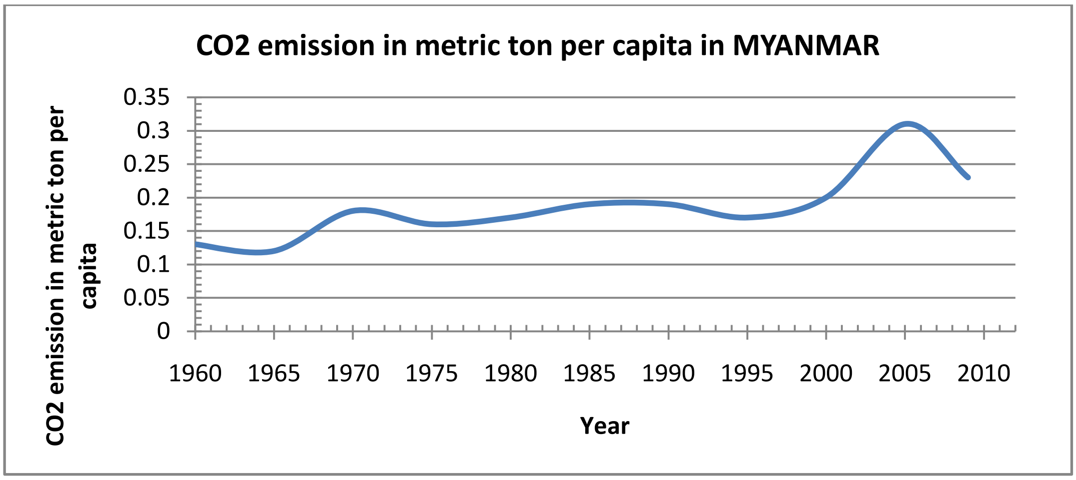


Figure 10: Co_2 emission metric ton per capita (Myanmar)

4.3 Discussion

As the global consumption rate, EF and population continues to increase, so does to Myanmar. Although the current EF of Myanmar is still less than the BC which creaste the ecological surplus, Myanmar should focus for the long term development and consider for sustainable development of environment, economic and social perspectives. Sustainability requires demand remaining within the regenerative capacity of nature. Sustainable development means that development that meets the needs of the present without comprising the ability of the future generations to meet their own needs (World Commission on Environment and Development, WCED). The following part will be the discussion of the Myanmar sustainable development plan for forest, agriculture, freshwater management, sustainable solid waste management and energy.

4.3.1 Forest sector: About 50 percent of Myanmar's total land area is covered with forests and it is an important role for both the country's economic and social development. It also reduces by sequestering the carbon dioxide in the atmosphere. However, Myanmar, as like other developing countries suffer the challenge of deforestation due to pressure for population and economic growth, urbanization, agriculture expansion and other factors. The demand for fuel wood and charcoal for cooking rise according to the population increases. The cuttings of trees are more occur near the villages and towns. In addition, illegal logging of valuable trees become seriously in some areas. This will cause land degradation and deforestation. To reduce this problem, the villagers usually practice a shifting cultivation particularly in the Kachin, Kayah, Kayin, Chin and Shan States. Most of the shifting cultivators are not notice any damage to the environment in the long run. They have only attention to get more food production in their farming and they don't aware they destroy many timber species and soil quality in their process. As a result, soil fertility depletion and soil erosion are occurs. To reduce this case, taungya system are used to grow their crops in the annual plantation.Taungya means upland fields or upland farming as Myanmar word. Community forestry and agroforestry are used as another control measure to reduce deforestation, soil erosion and land degradation. For watershed area crop growing, terracing methods, contour planting methods are used to reduce erosion. Forests, trees and plants are one of the most important factors for economic, social and environmental perspective. Therefore, government should have law enforcement to reduce illegal logging and encourage for activities such as growing trees and plants, reforestation, sustainable consumption of wood products, etc.

4.3.2 Agriculture sector: The overall development of Myanmar's national economy is highly depended on agriculture. As it is an agricultural country, local agro-based industries and export mainly depended on the raw materials from agriculture. Nearly 70 percent of total population are living in rural areas and mainly dependent on monoculture agriculture. More than 60 percent of total labors are agriculture and related industries. Recently, the rice-fish farming is being introduced and promoted. For sustainable agriculture development, it is needed to give training for rice-fish cultivation, hillside farming, preservation and sustainable land use practice. And it is also needed to share knowledge and should encourage for using of modern agro-technologies, composting method, organic farming and biofertilizers application.

4.3.3 Freshwater Management - Freshwater resources are importance for environment and economic perspective. Myanmar has 880.6 cu km of annual internal renewable fresh water resources. Main River are Ayeyarwady, Chindwin, Sittaung and Thanlwin .There are 6500 km of inland navigable waterway. Freshwater is heavily influenced on all economic and social. Myanmar also faces the freshwater issues such as inadequate water supply, water pollution from industrial and domestic wastes. The quantity and quality of water is mainly importance for environment, social and economic activity. Water pollution can cause from agricultural sources and excessive use of chemical fertilizer and pesticides. Therefore, the planning and management of water supply and sanitation systems as well as promoting for organic farming must be materialized. The improvements of aquatic ecosystem are very important as many rural farmers depend on protein source from the river.

4.3.4 Sustainable Solid Waste Management Planning-As Myanmar has not serious environmental pollution due to less industrial development. However, currently, solid waste management is regarded as one of the most immediate environmental issues. The compositions of municipal solid waste in Myanmar are mainly of organic waste (73%), wood (4%), paper/cardboard (18%), plastic and textile (2% each) and others (1%) (2ndMeeting of the Regional 3R Forum (4 -6 October 2010). Solid waste management consists understanding of current waste management practices as well as adoption of new methods for sustainable solid waste management approach. To generalize or standardize of solid waste management is difficult due to the various degree of consumption rate, life style and development of different countries. Low income region is generated solid waste lower than high income region. In Myanmar, municipal solid waste generation rate is increasing year after year due to the population growth, rapid urbanization, change in consumption and life styles, public unawareness and economic growth. The current recycling of municipal solid waste is not completely developed. The budget allocation and financial supports are also needed to fulfill sufficient facilities. And also improvement of sustainable solid waste management planning is also needed in Myanmar according to the population increasing and economic growth, etc. To approach sustainable solid waste management planning, it should be considered seven factors as financial, economic, institutional, technical, legal, social and environmental factors. According to (Ana et al. 2010), the sustainable management of solid waste is necessary from planning to design, to commission, to operation, to shut down, and to decommissioning. Hence the range of new and existing waste management technologies and strategies has also spanned from preserving environmental quality as on date to meet goals of sustainability in the future.

The legislations and regulations are also important in solid waste management and waste reduction. There are two type of environmental legislation. They are resource/wild life conservation, and pollution/ waste control laws (Ramesha Chandrappa. Diganta Bhusan Das, Solid Waste Management (Principles and Practice). To reduce the source of waste production, the manufacturers and designers should be measured the amount of toxicity of waste from the products. The amount of waste generating from the product production, during application and after application should be measured. The amount of waste from products can also reduce by improving technology and change the product’s design. The excessive consumption, mining and pollution during manufacturing and consumption of new product can cause resource reduction and so sound solid waste management will reduce these problems. The extremely extraction of mineral resources will be reduced by using sound solid waste management system such as proper recycling and reusing. This recycling and reuse of solid waste can also positive effect on conservation of species, forest and vegetation clearing, GHGs emissions and ecology, etc.Reduce, Reuse and Recycle (3Rs) Principle is also important to reduce solid waste generation rate. Waste minimization will get benefits such as raw materials costs reduction, increased productivity and also decrease energy cost.

4.3.5 Energy-To improve the quality of life, social and economic development, energy is an essential factor to be considered .Sustainable use and production of energy is needed to approach sustainable development plan. Myanmar has natural resources for production of energy. However, as the increasing of population and industrialization, the demand for energy is also increasing all the time. To approach sustainable development, energy should be focused on renewable sources such as wind, solar, tidal, etc.

4.4 Policy Instruments both legal and economic measure

For environment and social and long-term economic growth, the sustainable consumption and production are important. Sustainable means that both for the environmental (pollution, waste, resource use) and social (health, welfare) characteristics of products. Most government policies and instruments such as regulations and taxes, standards, subsidies, communications campaigns, education focus to reduce the environmental impacts of unsustainable production and to encourage the sustainable consumption**.**While environmental sustainability is an integral part of the National Sustainable Development Strategies (NSDS), protection of the environment and economic growth are often seen as competing aims. New policy should focus on the green economy—the financial benefits of increased eco-efficiency and the emergence of eco industry challenge the national environmental regulation. Society cooperation and participation is one of the most important factors to approach sustainable development of a country. After being economic developed, the environment will occur problems such as climate change. Therefore, to approach the sustainable economic development, we should also consider the legal and economic policy to ensure the proper environmental management as following:

1. Economic incentive-based (I-B) instruments for environmental management
   (Sources: An Introduction to Ecological Economics Book)
   - Taxes on pollution emissions (Pigovian taxes or charges)
   - Product charges (levied on products whose use causes environmental damage, such as CFC's, carbon fuels, agricultural chemicals and fertilizers)
   - Subsidies for pollution abatement (similar to taxes in concept but not in distributional consequences) especially for agriculture and sewage treatment
   - Marketable permits for pollution emissions
   - Creation of property rights for open access and other environmental resources
   - Creation of economic incentive
   - Subsidies for R&D of sustainable technologies
   - Subsidies for non-renewable energy to renewable energy

2. Natural Capital Depletion (NCD) Tax: A broad natural capital depletion tax is used to prevent the degradation of natural resources. The natural resources extracted from the environment to the economy are sustainable while strong incentives are given to develop new technologies and to change the environmental friendly processes in the manufacturing design (Costanza and Daly 1992).

3. Precautionary polluter pays principle (4P): These principles are used to prevent the impacts of pollution and technological innovation from the economic activities. We take raw materials from the environment as input for the economy activities and after

that we discharge pollution and wastes into the environment as output from the economy (Costanza and Cornwell 1992).

4. Ecological Tariffs: It is used for trade sustainable .However, it is needed to negotiate and agreement among the countries

5. Valuation of Non-Market goods or Economic Valuation of the Environment and Ecosystem Services (e.g. Market prices method, Contingent valuation, Recreation Demand, Hedonics and etc).

5. Conclusions

According to the economic development; sustainable development is needed to be considered. The main goal of sustainable development is to balance the fulfillment of human needs with the protection of the natural environment so that these needs can be met not only in the present, but in the indefinite future. To achieve this goal, we will reduce overconsumption, grinding poverty, to maximize economic production (green economy) and social equity. Without a measure tool as ecological footprint and biocapacity, more and more depletion of natural capital and biodiversity will occur. Environmental protections should be the basic objective in seeking development.Environmental sustainability means that the maintenance of the ecosystem and the natural resources. If environment are not properly managed, the environment degradation such as depletion of resources; pollution and biodiversity reduction will occur. As the environmental awareness gradually increase, natural resource conservation projects would be carried out at present.

According to the Myanmar National Environmental Policy Myanmar Agenda 21, environmental consideration will fill into the national economic development and will come into exist in the near future with principle of sustainable development in each sector of Myanmar. For the sustainable development approach of Myanmar, it is focus on development of green economy. As a developing country, Myanmar needs the supporting from developed countries to approach the sustainable green technology (e.g renewable energy). The main goal of economic policy is to get balance and proportionate growth. The technical training and education programs are help not only to increase productivity in business society but also people to the practices of cooperation, coordination and collaboration. If it is not equitable, development is not sustainable. In Myanmar, equal access for all peoples in both central and border regions should be necessary. Education and health services development programs are also should be considered for social development. For the infrastructure, communication and urban as well as in industry and tourism, new technologies which allow Myanmar to improve current situation. However, it is also regarding to build less carbon content future. If renewable sources are used in long term, many problems associated with natural resources will occur. Therefore, life cycle assessment (LCA) of each product should be considered. Similarly, Myanmar’s agriculture, ago-based industries and eco-tourism will also consider to increase value and to meet sustainable development.

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AN INDIGENOUS SWIRL TYPE GAS BURNER FOR LPG / CNG / BIOGAS

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ABSTRACT

Different types of swirl-burners are required for various industrial and other uses. The primary objective of the present investigation is to develop an indigenous swirl type gas burner which may be used for burning of LPG, CNG, Biogas or the like in a better way. In the present study, the new burner is designed, physically developed and tested. All the design dimensions are given with appropriate sketches and figures.

The new burner basically consists of a stainless steel barrel with removable brass funnel having exit nozzle at its top. Discharge pipe of a centrifugal blower is fitted with barrel near the bottom end. The gas connecting steel pipe with nozzle orifice is vertically placed at the central position of barrel bottom through a screwed socket. The steel gas pipe is provided with an adjusting cock and is connected with gas hose coming from LPG cylinder in the present investigation. Of course, this present LPG gas burner can easily be converted to CNG or, Biogas burner simply by replacing nozzle orifice of different diameters and gas regulator.

The originality of the present burner is that here at a comparatively low cost perfect homogeneous mixing of gas and air is achieved through an indigenous mixing process. The present design is practically suitable for any type of gaseous fuel or, liquid fuel in gaseous form. The proposed swirl vane technology which has been designed and used in the present burner is not exactly the same i.e., different from readily available similar types of swirl burners. In the present burner, the supply of air and gas can be properly controlled through controlling of air delivery from blower and by controlling the rate of gas flow by gas regulator. The fabrication cost of the burner without the centrifugal blower is about 50 USD (US Dollar). Some initial tests are carried out with the burner using LPG. Initial test results indicate the thermal efficiency of about 40 %.

Finally, it may be concluded that with its distinctive design features the present burner results in better homogeneous air-gas mixture. Due to swirling motion of flame, the residence time of flame with heating surfaces is increased and with proper control of gas-air ratio, thermal efficiency is enhanced with reduced rate of harmful emissions.

Keywords : Swirl, Gas Burner, LPG

INTRODUCTION

Swirling flow burners are essential to both premixed and non-premixed combustion systems because of their significant beneficial effects on combustion performance. Different types of swirl burners are available for various industrial and other uses. Characteristics of swirl flow burners have been investigated from different angles over the years by many researchers. Among them, study of combustion and other performance characteristics in swirling flow [1,2,3], the influence of swirl burner structure on the gas flow and flame characteristics etc. [4,5,6] are important. In the present study an indigenous swirl type gas burner which can be used for burning LPG, CNG, Biogas or the like has been designed, physically constructed and tested.

CONSTRUCTIONAL DETAILS OF THE BURNER

The new burner consists of a stainless steel barrel with removable brass funnel having exit nozzle at its top. Discharge pipe of a centrifugal blower is fitted with barrel near the bottom end perpendicularly with the vertical axis of the burner. The gas connecting steel pipe with nozzle orifice is vertically placed at the central position of barrel bottom through a screwed socket. The steel gas pipe is provided with an adjusting cock and is connected with gas hose coming from LPG cylinder in the present investigation. Of course, this present LPG gas burner can easily be converted to CNG or, Biogas burner simply by replacing nozzle orifice of different diameters and gas regulator. One of the unique features of the burner is that a mixing tube with air entrance cone at bottom end is centrally placed inside of the burner barrel and gas nozzle is placed inside of entrance cone, where the cross sectional area of air entrance cone at bottom position is half of the inner cross sectional area of barrel. Detail construction features of the presently developed burner are shown in Figure:1.

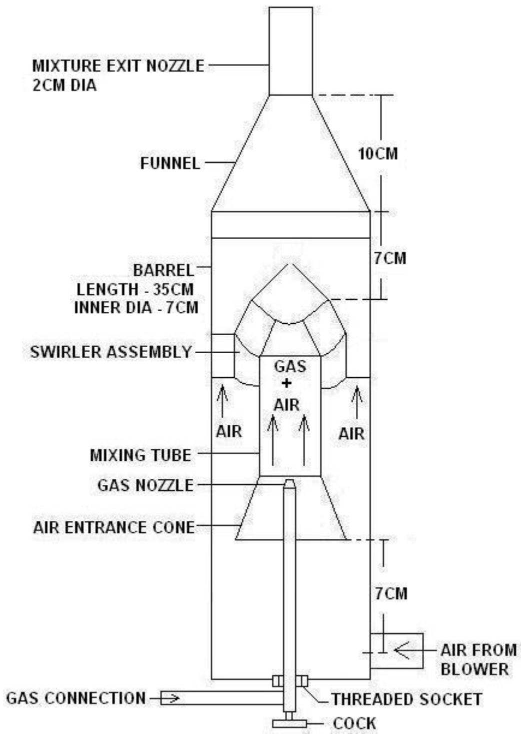
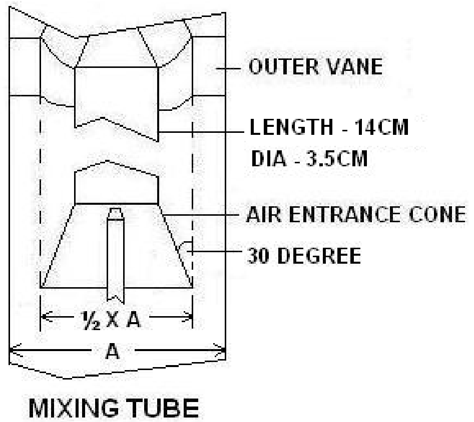


Figure 1. – NEW BURNER

The co-axial swirler assembly of the burner is placed at the upside of the mixing tube. The swirler assembly is designed in such a way that it consists of a horizontally placed outer swirler with 60 degree straight vanes and an inner swirler with 30 degree straight vanes radially arranged at an inclination of 30 degree with the vertical plane. Inner swirler is located just above the outer swirler. Angular position of outer swirler vanes and radially placed inner swirler vanes are built directionally opposite. A hemispherical deflector is provided at the top of the mixing tube which guides the air-gas mixture for smooth entry into the inner swirler blades. Another deflecting section is provided at the location of outer swirler air entrance region for smooth entry of air towards the outer swirler blades. A short height cone is attached at the top of the inner swirler mixture deflector. Burner components are shown in Figure:2. A photograph of swirler assembly with mixing tube is shown in Figure: 3.



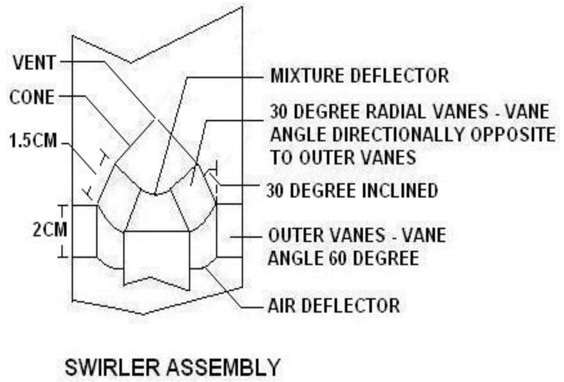


Figure 2. – BURNER COMPONENTS

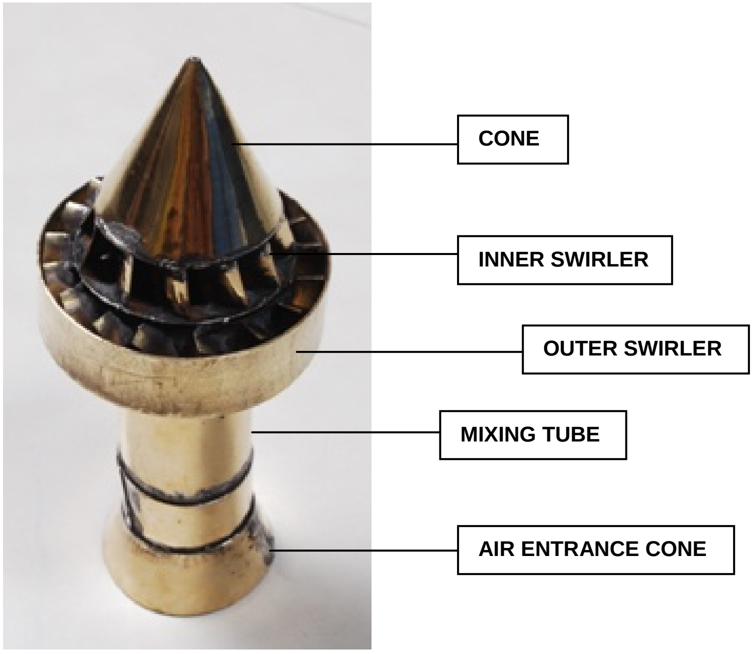


Figure 3. – SWIRLER ASSEMBLY WITH MIXING TUBE

OPERATION OF THE BURNER

Nearly 50 percent of the pressurized air supplied by blower is entered into the mixing tube and mixed with high velocity gas jet exits from gas nozzle. Rich gas-air mixture is formed inside of mixing tube. The hemispherical deflector at the top of the mixing tube guides the gas-air mixture through the inner swirler vanes. As the angular position of swirler blades of radially placed inner swirler and horizontally placed outer swirler are directionally opposite so, swirling rich mixture exits from inner swirler tangentially penetrates into the oppositely rotating fresh air coming out from outer swirler and mixed thoroughly to form perfect homogeneous pre-flame mixture. Mixture is then reached to burner exit nozzle where it is burnt. Chemically correct pre-flame mixture can be formed through precise control of both air and gas by adjusting blower speed and gas regulator to achieve blue flame combustion.

Swirl number of inner swirler is kept far less than swirl number of outer swirler. Again the quantity of air and mixture flow through outer and inner swirler is approximately same. As a result even the density of rich gas-air mixture exits from inner swirler is greater than fresh air coming out from outer swirler, the ultimate rotational direction of pre-flame mixture inside of barrel maintains the same direction of rotating air which exits from downstream side of outer swirler dominating oppositely rotational motion of rich mixture. As the inner swirler is 30 degree inclined to the vertical so the swirling mixture coming out from inner swirler follows 30 degree helical path towards burner exit and outcoming mixture thus coincides from opposite direction with the 30 degree helical path of swirling air exits from outer swirler arranged with 60 degree vane angle.

A deflecting section is arranged at the location of outer swirler air entrance region for smooth entry of air towards the outer swirler blades.

The cone at the top of inner swirler mixture deflector is provided to reduce the vortex breakdown effect. Normally, vortex breakdown phenomenon improves mixing process but in the present burner it has been observed that, without implementation of the cone, generated vortex breakdown is so high that it badly affects on swirling motion of pre-flame mixture.

In short, the newly developed burner design features and thereby, its operational methodology help better mixing of air-gas and ultimately results in better combustion.

SPECIFICATIONS OF THE PRESENT PROTOTYPE

Dimensions

Outside diameter of burner barrel = 7.4 cm.
Barrel wall thickness = 0.2 cm.
Height of the burner barrel = 35 cm.
Height of the barrel above swirler assembly = 7 cm.
Height of funnel section = 10 cm.
Funnel wall thickness = 0.2 cm.
Mixture exit nozzle diameter = 2 cm.
Inner diameter of gas nozzle pipe = 1.25 cm.
Inner diameter nozzle orifice = 0.06 cm.

Length of the gas nozzle pipe = 13 cm.
Inner diameter of gas supplying rubber hose = 0.7 cm.

Required length of the barrel above swirler assembly for one complete turn at 30 degree helical path = axial distance covered by one complete turn of helical path of 30 degree helix = tan 30degree x ת x inner diameter of barrel = 0.5774 x ת x 7 = 12.7cm, height of the barrel above swirler assembly is kept 7cm to minimize the total height of the barrel but as height of the funnel is 10cm with only 30 degree inclination so, a complete rotation of swirling mixture is achieved. Swirling motion at the upper part of the funnel will be disturbed for restricted passage but as the diameter of funnel is continuously reduced; required length for one complete turn of swirling mixture at 30 degree helical path will be actually less than 12.7cm as calculated.

Distance between blower air intake pipe and mixing tube is kept equal to the inner diameter of barrel, i.e. 7cm.

Mixing tube diameter = 3.5 cm.

Maximum diameter of mixing tube air entrance cone = 5cm (cross sectional area at entrance = ½ of the cross sectional area of barrel inside).

Mixing tube length = 14 cm.

Swirler geometry

Swirl vane design for both inner and outer swirlers : straight vane type.
Blade angle of outer swirler = 60 degree.
Blade angle of Inner swirler = 30 degree.
Inner swirler blades are radially placed just above the horizontally placed outer swirler at an inclination of 30 degree to the vertical plane.
Angular position of inner and outer swirler blades is directionally opposite.
Number of blades of inner swirler = 11 nos.
Number of blades of outer swirler = 17 nos.
Hub diameter of inner swirler = diameter of mixing tube = 3.5 cm.
Outer diameter of inner swirler = maximum diameter of mixing tube air entrance cone = 5 cm.
Slant height of inner swirler blades = 1.5 cm.
Hub diameter of outer swirler = outer diameter of inner swirler = 5 cm.
Outer diameter of outer swirler = Inner diameter of barrel = 7 cm.
Depth of the outer swirler = 2 cm
Swirl number of inner swirler = 0.5
Swirl number of outer swirler = 1.5

Equation applied to find the swirl number for straight vane type swirler assembly :

$$S = (2/3).[\{1-(d_h / d_0)^3\} / \{1-(d_h / d_0)^2\}].\tan\theta \quad (1)$$

where, S is the Swirl number, $d_{h,}$ d_0 are hub diameter and outer diameter of swirl vanes respectively. θ is the swirl angle.

PROCESS OF MANUFACTURE OF DIFFERENT COMPONENTS OF PROTOTYPE

1. Burner barrel is made of stainless steel pipe.
2. Funnel is made of brass sheet.
3. Mixture exit tube is a brass pipe.
4. Swirler assembly and mixing tube are fabricated by 0.1cm thick brass sheet. (In the present prototype, swirler assembly is fabricated by brass sheet. Soft soldering is presently used for swirler assembly formation. It is to be fabricated through molding process in actual prototype and will be made of brass material).
5. Blower No-14, driven by ½ H.P motor is used in the prototype.
6. Conventional high capacity gas pipe, gas hose those are commonly used for commercial cooking in hotel kitchens, restaurants are directly used in present prototype.
7. Burner barrel stand is fabricated by M.S. strips.

TESTING OF THE PRESENT BURNER

Thermal efficiency of the burner following Indian Standard (IS)- 14612: 1999 (reaffirmed on 2008) [7] is calculated several times. The average efficiency of the burner is calculated as 42.2%. Here one detail sample calculation is shown.

Thermal efficiency calculation procedure following the code methodology

Thermal efficiency of the burner is calculated by the formula :

$$\text{Thermal efficiency \%, } \eta = [\,(G + W) \times (T_2 - T_1) \times 100\,] / [\,M \times K\,] \qquad (2)$$

where,

G = Quantity of water taken in the aluminum cooking pan (kg)
W = Water equivalent of the pan complete with lid and stirrer (kg)
= (Weight of cooking pan plus lid and stirred , kg) x Specific heat of Aluminum (0.214)
T_1 = Initial temperature of water in ^oC (within 20 to 30^oC)
T_2 = Final temperature of water in ^oC (90 ± 1^oC)
M = Gas consumed to heat up the water in pan to raise water from T_2 to T_1 (kg)
K = Calorific value of LPG (in Kcal/Kg) = 10900 Kcal/kg = 45636 KJ/kg

Equipments, Materials and Dimensions of materials Used for Test

Diameter of flat bottom cooking pan = 22 cm
Height of the pan = 11 cm.
Wall thickness of the pan = 0.2 cm.

Material of the cooking pan and lid - Aluminum.
Diameter of cooking pan support = 15 cm.
Distance of the cooking bottom from burner exit nozzle = 7.5 cm

Measuring instruments required for test

1. Typical Pressure gauge as used for measuring pressurized air.
2. Mercury Thermometer.
3. Stop Watch
4. Weighing machine

Test Calculations

LPG gas pressure in gas cylinder = 5.5 kg per sq.cm (by measurement).
Gas pressure at downstream side of the gas regulating cock during test = 1.5 kg per sq.cm.
G = Mass of water taken in the cooking pan = 16.5 kg
Weight of empty cooking pan = 1.4 kg
Weight of empty pan along with lid and stirrer = 2.5 kg

W = Water equivalent of cooking pan complete with lid and stirrer = 2.5 x Specific heat of Aluminum = 2.5 x 0.214 kg = 0.535 kg.
T_1 = 25 ^oC (measured by thermometer)
T_2 = 90 ^oC (measured by thermometer)
M = Mass of Gas (LPG) consumed to raise temperature from T_1 to T_2 (by measurement)
= 0.240 kg.
Time required for this gas consumption (measured by stop watch) = 8 min 10 sec = 8.166 min.
Gas consumption rate = 0.240 kg per 8.166 min = 1.7634 kg / hour
Thermal efficiency of the burner , η = [(G +W) x ($T_2 - T_1$) x 100] / [M x K] %
= [17.035 x (90 – 25) x 100] / [0.240 x 10900] %
= 42.32 %
The flame condition was stable and blue in colour.

APPLICATION AND COST

At comparatively low cost, the present design is suitable for any type of gaseous fuel like LPG, CNG, Biogas or, liquid fuel in gaseous form. By simply replacing the gas nozzle orifice of different diameters and gas regulator, this design can be used for different types of gaseous fuels. It may be noted that for less clean gas like unprocessed Biogas, or CNG this design is highly suitable. Present design can be applied for industrial applications like industrial process heating, in hearths, dryers etc.

The overall fabrication cost of the present prototype is approximately 140 USD (US Dollar), where the centrifugal blower cost itself is about 90 USD. Obviously, for an industrial size design the cost will be much more and yet not been estimated.

CONCLUDING REMARKS

1. At comparatively low cost, the presently proposed burner is based on an indigenous swirler assembly which is different from readily available types of swirler burners. Here mixing operation to generate pre-flame mixture of air and gas are completed in two stages. In the first stage of mixing, rich mixture is formed in a mixing tube. Thereafter, the rich mixture is mixed with fresh air coming through a swirler assembly to form chemically appropriate pre-flame mixture for proper combustion. Stable flame is achieved.
2. Due to swirling motion, the residence time of flame with heating surfaces is increased resulting better heat transfer.
3. Again, with proper control of gas-air ratio, thermal efficiency is enhanced resulting reduced rate of harmful emissions.
4. The newly developed burner can be used for any type of gaseous fuel like LPG, CNG, Biogas or, liquid fuel in gaseous form just by changing gas nozzle and gas regulator. Similarly, this burner with appropriate sizes can be applied for various industrial purposes.

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An Experimental comparison study between Single-Axis Tracking and Fixed Photovoltaic Solar Panel Efficiency and Power Output: Case Study in East Coast Malaysia

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ABSTRACT

A sustainable energy supply is required in Malaysia to meet the increasing electricity demand with rapid growing in population and economy. Photovoltaic solar panel is most suitable alternative way to generate electricity in Malaysia where most of its location receives large number of solar radiation throughout the year. However, fixed solar panel is more preferred than tracking panel because it is cost effective. In present work, the power output and efficiency of single-axis tracking solar panel is compared with fixed solar panel by experimentally in East Coast Malaysia. A single-axis tracking panel produces higher power output than fixed panel up to 28W. During this time, the average efficiency of tracking panel was about 66.70% and fixed panel was 39.96%. Hence, the percentage increment on average power output using tracking panel reached up to 66.92% compare to fixed panel during this period. The tracking panel module efficiency was higher than fixed panel for the same period and can reach up to 28.9% at 6.00p.m. In conclusion, single-axis tracking panel is more efficient than fixed panel in premeridian and postmeridian. Thus, it produces higher power output than fixed panel which means it utilize the most of available solar radiation effectively and this will reduce payback period of the initial investment cost.

Keywords: Single-Axis, Solar Tracking, Solar radiation.

INTRODUCTION

A sustainable energy supply is required in Malaysia to meet the increasing electricity demand with rapid growing in population and economy. Solar energy is the most potential renewable energy in Malaysia, whereby most of its location receives abundant solar radiation yearly [1]. The photovoltaic (PV) solar panel is an alternative way to generate green electricity and becoming one of popular technology in Malaysia. Typically in Malaysia, stationary PV solar panel is installed at fixed position at rooftop of a building to harness energy from solar irradiation during daytime throughout the year. Conversely, Bari [2] noticed that not all Malaysian domestic consumers installed their PV solar panels at an optimum orientation and tilt angle. Eventually, it reduces the incoming solar irradiation onto panel to 10-35% less than properly installed solar panel. Thus, an optimum orientation and tilt angle can increase the yearly gains for installed fixed solar panel.

However, the properly installed fixed panel is also operating less efficient at some point compared to tracking panel due to sun’s motion on daily and yearly basis. Therefore, employing a tracking panel will generate higher electricity and more efficient as compared to fixed panel [3-5]. The performance of passive tracker using mechanical system has been found to be comparable to active tracking system. Even so, passive tracker system has not yet been widely accepted by the consumer even though the cost is often less expensive [6]. Abdallah [7] perform an experiment to investigate the performance of vertical axis tracking system and horizontal south-north single-axis tracking system. He found that the performance of vertical axis was better than horizontal axis solar tracking system. A simple single-axis tracking solar panel was designed using PIC microcontroller for controlling the mechanical movement based on the predetermined position of sun [8-10]. The result shows that more than 20% daily power output is generated by tracking system in comparison to a fixed panel. The increment of power output of a solar tracking system was about 20 to 40% as compared to fixed solar panel. However, an external energy such as electrical and mechanical equipment is required to keep the solar panel position always perpendicular to the sun irradiation and transfer it into useful form of energy.

A horizontal single-axis tracking system was developed for this project. The purpose of this paper is to perform an experimental comparison study between single-axis tracking and fixed PV solar panel efficiency and power output in East Coast, Malaysia. The experimental study on a clear sky and partly cloudy day at this part of Malaysia has not been done yet. Furthermore, the module efficiency comparison between tracking and fixed panel has never been done yet.

METHODOLOGY

Experiment set-up and procedure

The experiment was conducted on a clear sky and partly cloudy day at 3.5˚N, 103.42˚E Pekan Campus, University Malaysia Pahang by using two units of PV monocrystalline solar panel with specification as shown in Table 1. The horizontal global solar irradiation was measured using calibrated pyranometer with maximum irradiance measurement up to 2000 W/m^2 and sensitivity of 5 to 20 $\mu V/W/m^2$. The both panels were installed side by side with an adequate space and tilting towards due south at angle of 10˚ as shown in Fig. 1. The voltage, ampere, power, and energy output from PV solar panel were measured using digital watt meter with maximum measurement up to 6554W and 0.1W resolution. Both PV solar panels have connected to digital watt meter separately and all the readings were taken simultaneously are recorded in an interval of 15 minutes from 9.00a.m until 6.00p.m.

Table1: Specification of PV Panel

Type	Value
Dimensions (mm)	980 x 445 x 35
Type	Monocrystalline
Weight (kg)	6.1
Number of cells	36 (12 x 3)
Max Power Output (W)	50
Power Tolerance (%)	±3
Module Efficiency (%)	10
Normal Operating Cell Temperature (˚C)	44.4±2

Development of Single-Axis Tracking system

The analysis of structural and selection of material for test rig were done using autodesk algor simulation. The CAD drawing in Figure 2 shows PV solar panel was attached to a hollow shaft that allows the panel to rotate at vertical axis. The hollow shaft was fixed to the bearing at base structural. A 12V DC motor with worm gears was used this project. The worm gears able to hold the PV solar panel in same position even though the motor is offline or no power supplied. A reduction gear chain system used to increase the torque output on shaft. The gear ratio was 40:12 or 3.33.

An active tracker type of single-axis tracking system was used to track the position of sunlight which includes a PIC microcontroller and electro-optical sensor. The single-axis tracking system was designed to track the sun position by comparing the analog signal from Light Dependent Resistor (LDR). The both LDRs were separated by acrylic board and its height adjusted to required sensitivity for the tracking system. Motor rotate clockwise if analog signal from LDR 1 is greater than LDR 2 and anticlockwise if vice versa. The motor keep rotates until the both LDRs analog signal are equal and then stop as shown in Figure 3. The solar tracking system follow the instantaneously sun motion at all the time and reset to its original position at 7.00p.m.

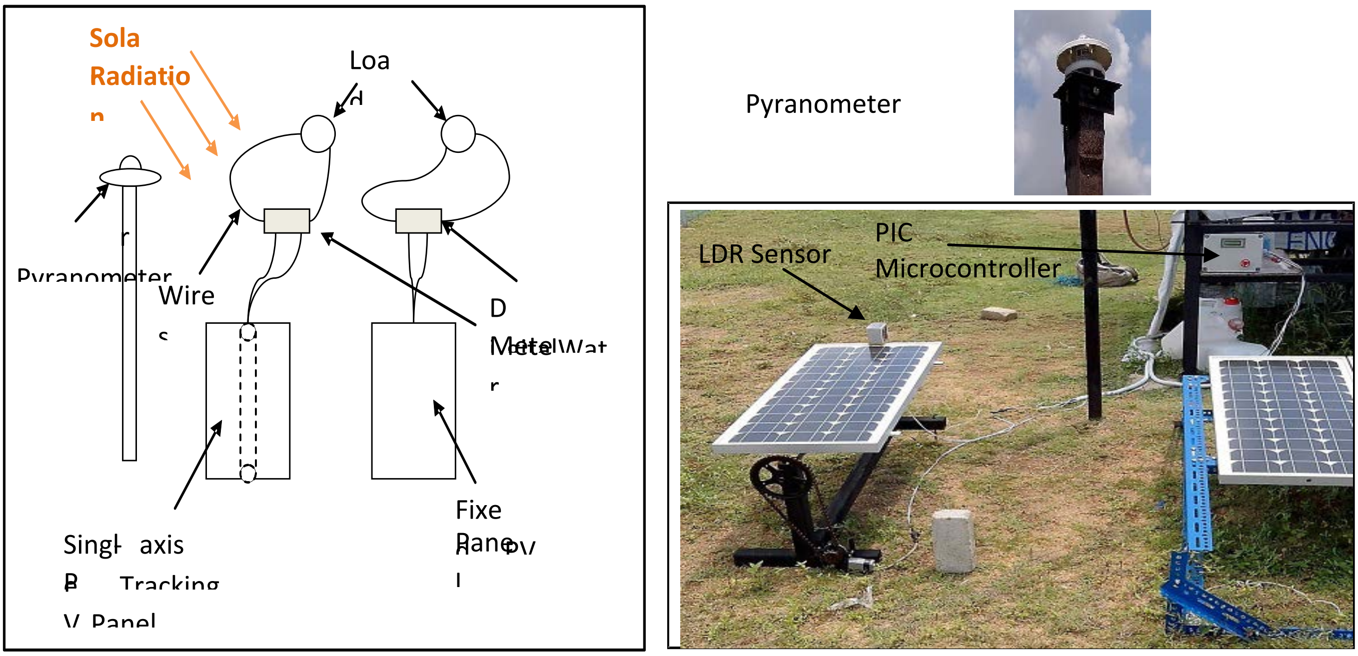

Figure 1. Schematic diagram and actual photograph of PV Solar Panels

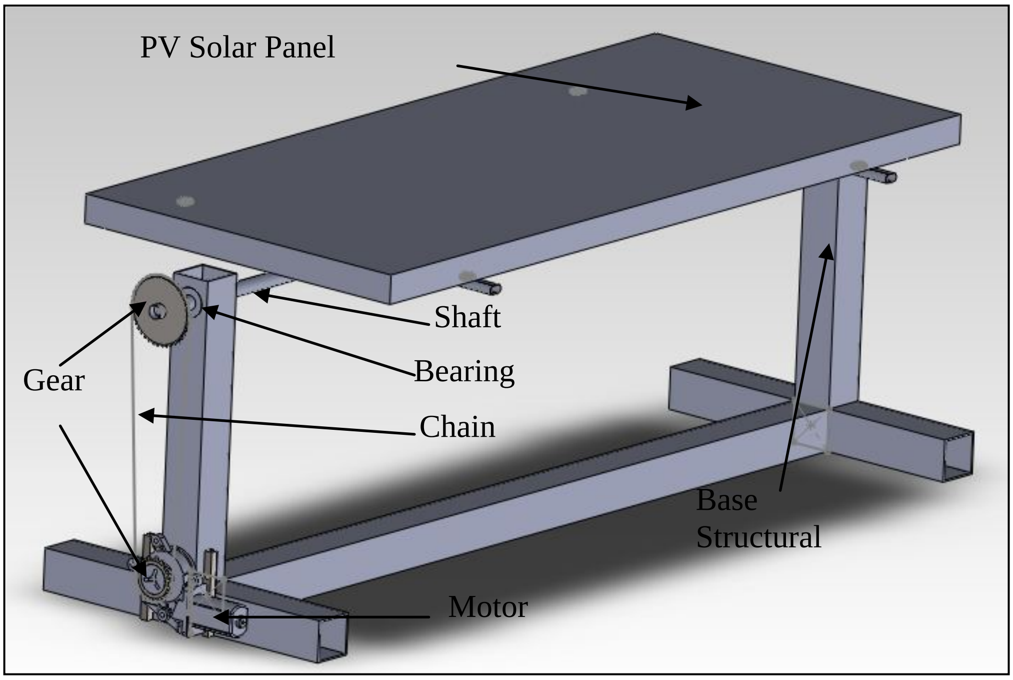

Figure 2. CAD drawing of Single-axis tracking PV

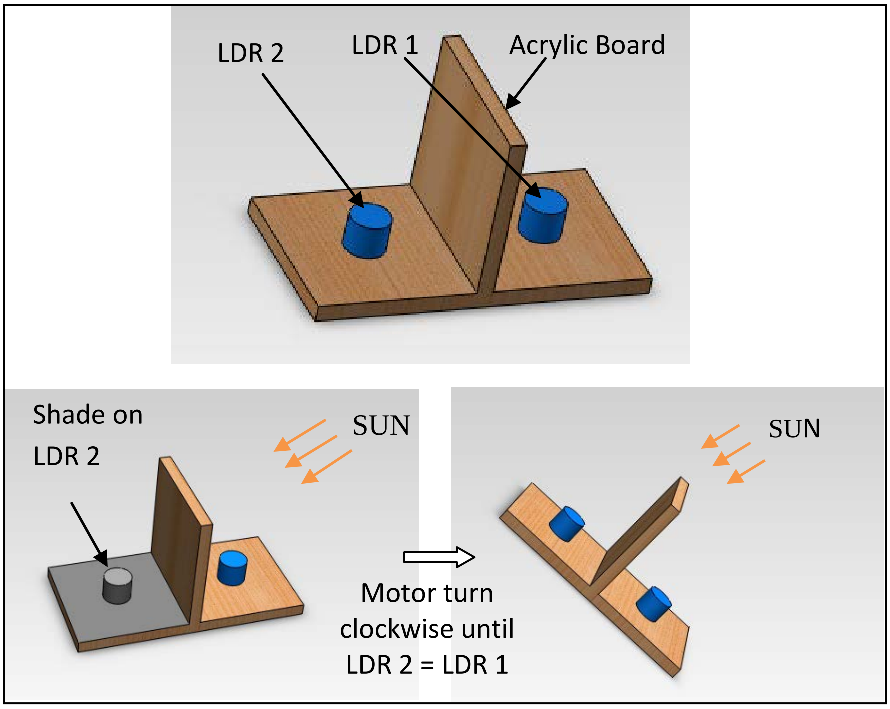

Figure 3. Tracking system working principle using LDR

Efficiency Calculation

The solar panel efficiency was calculated using Eq. 1[11];

$$\eta_p = \left(\frac{P_o}{P_{\max}} \right) \tag{1}$$

Where, η_p is PV solar panel efficiency, P_o is power output from panel and $P_{\max}$ is maximum power output of the panel.

The module efficiency of PV was evaluated using Eq. 2 [11];

$$\eta_m = \left(\frac{P_o}{A_c \cdot G} \right) \tag{2}$$

Where, η_m is module efficiency, P_o is power output from panel, A_c is area of PV solar panel and G is horizontal global solar radiation.

RESULTS AND DISCUSSION

On a Clear sky day

Experiment was conducted on a clear sky day and partly cloudy day. These two diurnal patterns were commonly observed in Pekan, Malaysia throughout the year. On a clear sky day, it was observed the solar irradiation increase steadily until it reaches its maximum intensity about 950W/m^2 by midday and gradually decreases after 3.00p.m and reached about 215W/m^2 at 6.00p.m as shown in Fig. 4. Meanwhile, the power output from single-axis tracking and fixed PV solar panel are also plotted in the Fig. 4. The single-axis tracking panel produce a steady power output approximately 30-35W throughout day from 9.00am until 6.00pm. This is because the tracking sensor always locates the maximum solar irradiation and point the panel towards its direction. In contrast, the fixed panel power output follows quadratic pattern as distribution of solar irradiation for the entire day. It was observed that before 11.00a.m and after 3.00p.m, the power output produced by fixed panel was uneven and comparatively smaller amount than tracking panel.

Nevertheless, fixed panel is also able to produce equal power output as single-axis tracking panel when sun position perpendicular panel during the midday. This is clearly shown in Figure 5 that during the midday additional power gain from single-axis tracking panel is less than 2.5W and nearly to zero. Furthermore, it was observed the additional power gain from tracking panel during morning and evening can reach up to 28W. Thus, the tracking solar panel is able to produce steady power output throughout the day whereas fixed panel is highly dependent on solar irradiation and its sun's position.

The total energy output for a clear sky day from single-axis tracking was 280Wh is shown in Figure 6. The tracking panel has produced about 32.7% higher energy output compared to fixed panel on the particular day. This finding is comparable with investigator discussed in literature earlier.

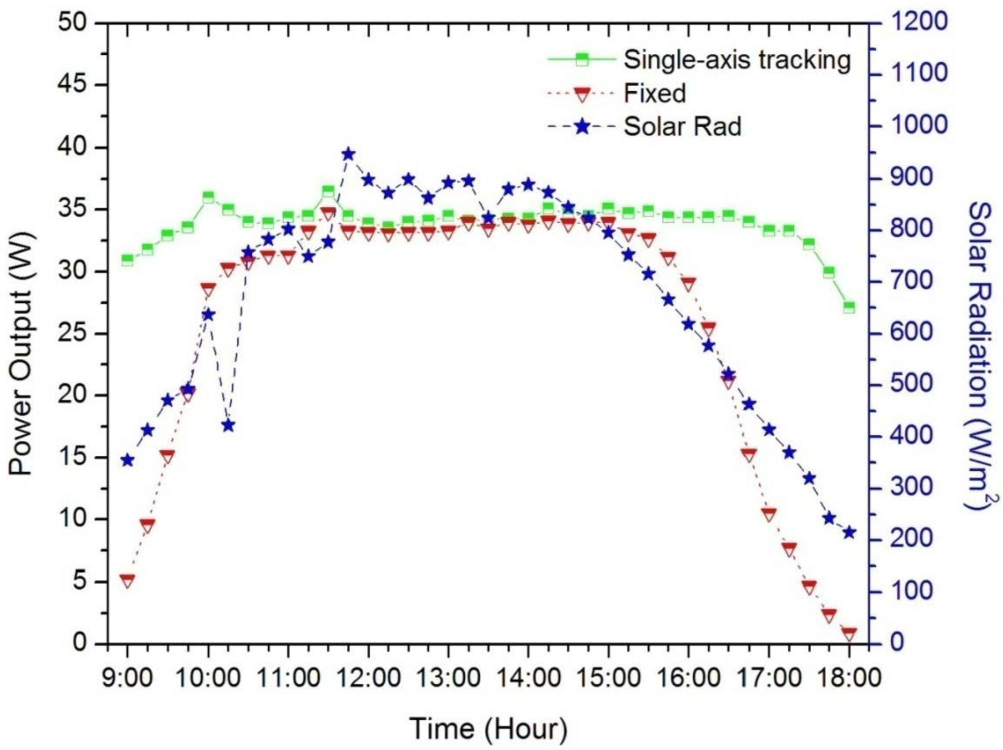

Figure 4. Power output comparison between single-axis tracking and fixed solar panel on a clear sky day

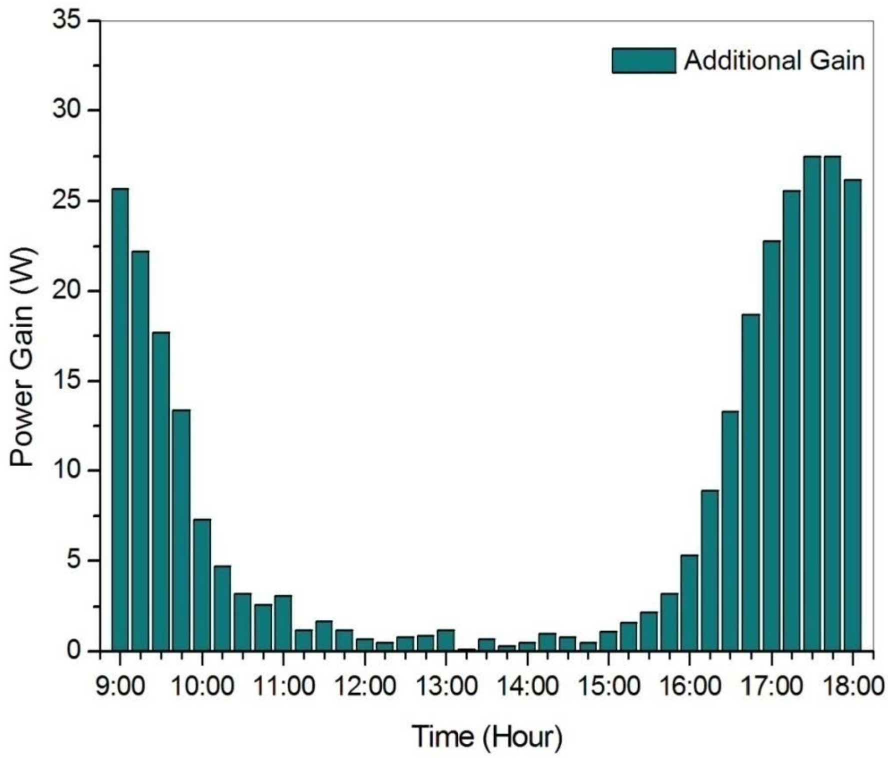

Figure 5. Additional power gain from single-axis tracking solar panel on a clear sky day

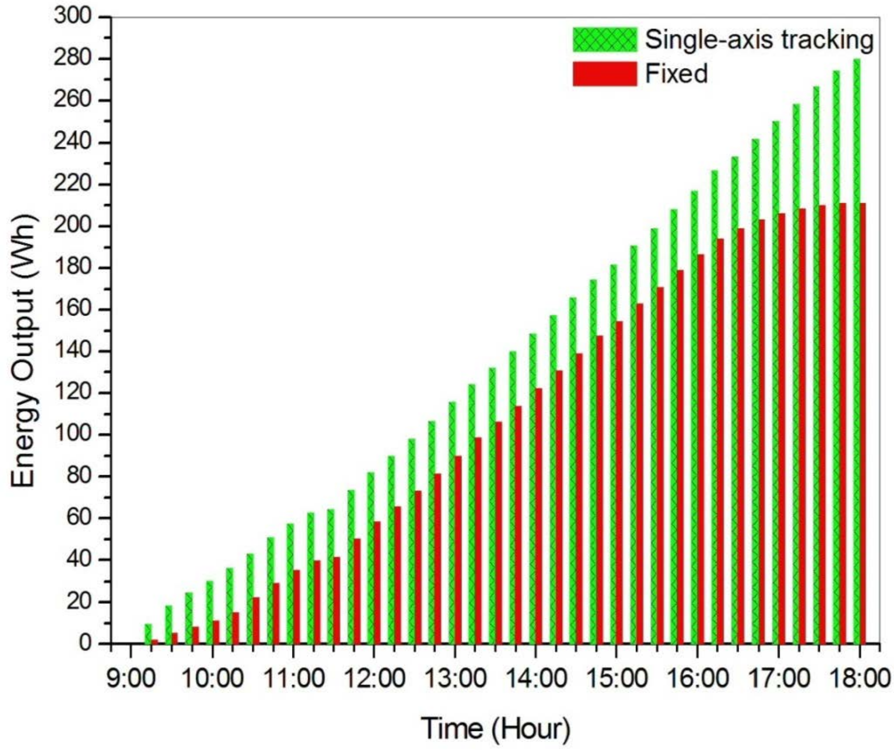

Figure 6. Total energy output from single-axis tracking and fixed solar panel on a clear sky day

On a Partly cloudy day

On the contrary, the solar irradiation on a partly cloudy has irregular pattern due to large number of passing clouds in morning and evening time. However, it reaches its maximum intensity about 1050W/m^2 by midday as shown in Figure 7. The solar irradiation pattern on this day is not predictable as it depends on degree of cloudiness at the time.

Hence, both tracking and fixed panel are not able to produce a stable power output before noontime. Nonetheless, tracking panel produces a stable power output during midday and evening about 35-37W. The power output was higher than clear sky day due to direct incoming solar irradiation after the clouds cleared. The fixed panel power output follows exact pattern as distribution of solar irradiation for whole day.

The most additional power gain from single-axis tracking panel on this day was after 3.00p.m to 28W 6.00p.m as seen from Figure 8. The total energy output for partly cloudy day from single-axis tracking was 242Wh is shown in Figure 9. The tracking panel has produced about 28.0% higher energy output compared to fixed panel on the day.

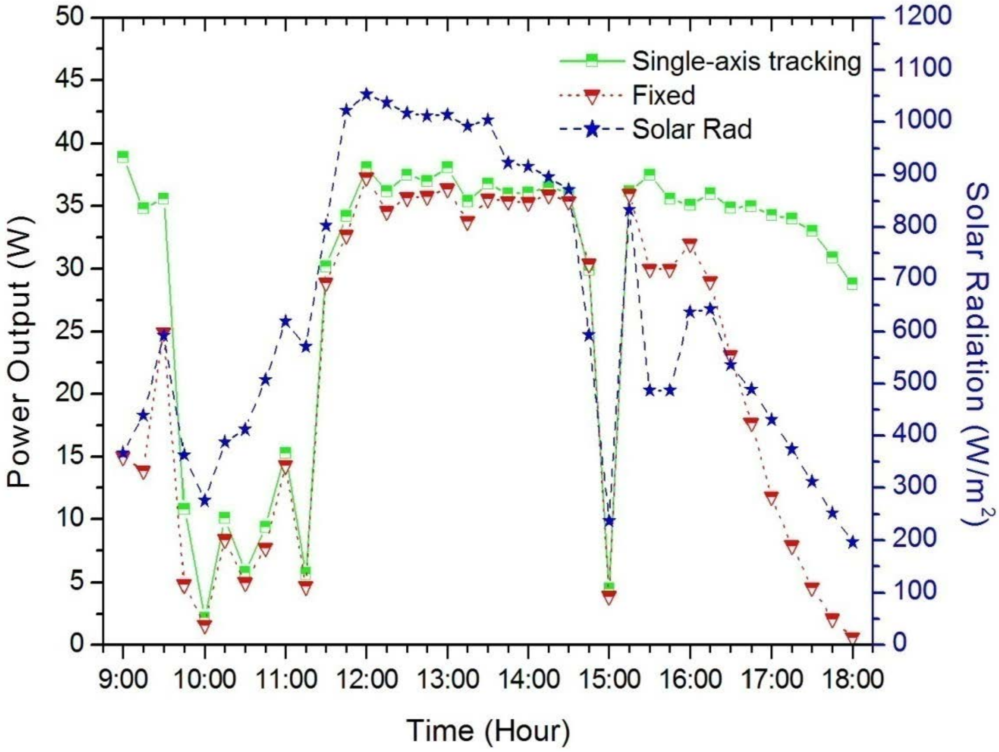

Figure 7. Power output comparison between single-axis tracking and fixed solar panel on a partly cloudy day

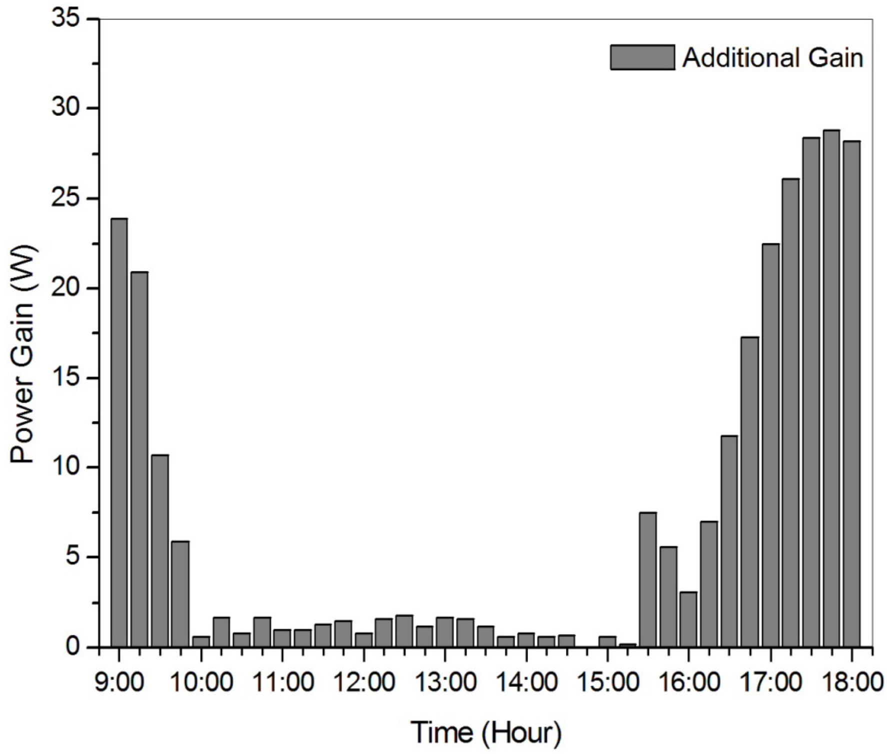

Figure 8. Additional power gain from single-axis tracking solar panel on a partly cloudy day

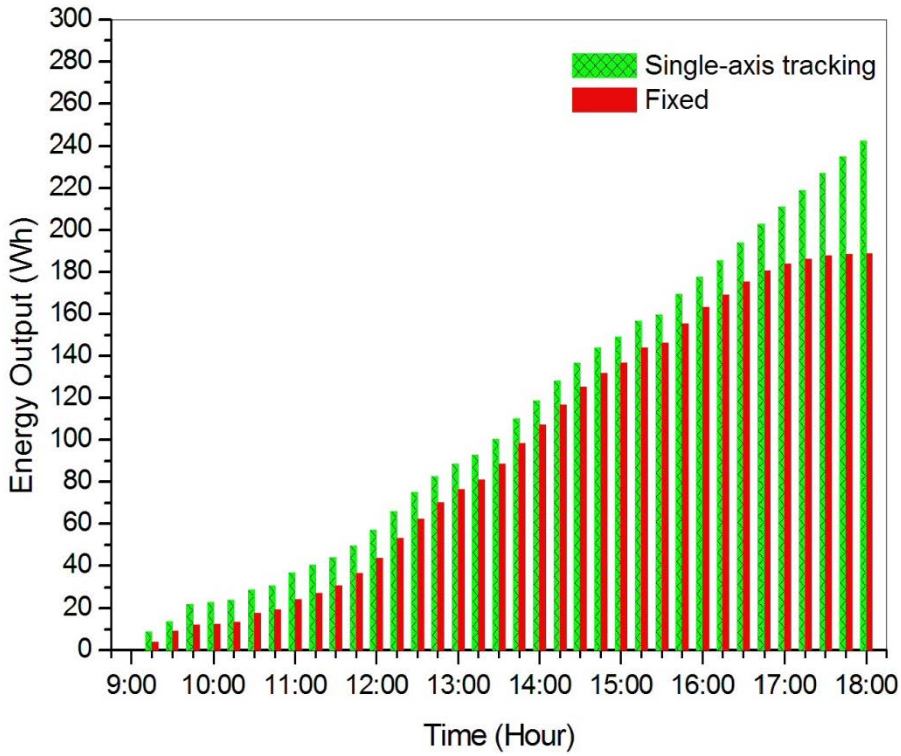

Figure 9. Total energy output from single-axis tracking and fixed solar panel on a clear sky day

Efficiency of PV solar panel

On a clear sky day, average panel efficiency for the single-axis tracking panel was about 67.65% for the entire day as shown in Table 2. Meanwhile, fixed panel was only about 51.65% for the same day. The percentage increase on average power output by the tracking panel over the fixed panel was 30.12%. However, tracking panel produce higher power output than fixed panel is before 11.00a.m and after 3.00p.m. During this time, the average efficiency of tracking panel was about 66.70% and fixed panel was 39.96%. Hence, the percentage increment on average power output using tracking panel reached up to 66.92% compare to fixed panel during this period. Similarly, the tracking panel module efficiency was higher than fixed panel at same period and can be reaching up to 28.9% at 6.00p.m as seen from Table 3. In addition, module efficiency of both panels were relatively equal during midday with maximum difference was only about 0.3%. This is because the both panels received equal amount solar irradiation from the sun and its direction was perpendicular to the panels. For partly cloudy day, average panel efficiency for the single-axis tracking panel was about 61.22% and fixed panel was only about 46.61% for the whole day. Thus, percentage increment on average power output was about 31.37% and it is comparable with clear sky day which was only 1% in difference. Even so, before 11.00a.m and after 3.00p.m the average efficiency of tracking panel was about 56.80% and fixed panel was 32.67%. Therefore, the percentage increment on average power output using tracking panel reached up to 73.81% compare to fixed panel during this time. Likewise, the tracking panel module efficiency was higher than fixed panel at sunset and reached about 33.7% at 6.00p.m. Besides, it was noticed that module efficiency both panels were follow the solar irradiation during midday and the maximum difference was only about 0.6%.

Table 2: PV Solar Panel Efficiency

Day Condition	Panel	Average of Entire day		Average before 11.00am and after 3.00pm	
		Average Power Output (W)	Average Panel Efficiency (%)	Average Power Output (W)	Average Panel Efficiency (%)
Clear Sky	Tracking	33.82	67.65	33.35	66.70
	Fixed	25.83	51.65	19.98	39.96
Partly Cloudy	Tracking	30.61	61.22	28.40	56.80
	Fixed	23.30	46.61	16.34	32.67

Table 3: Module Efficiency

Day Condition	Panel	Time									
		9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm
Clear Sky	Tracking	20.0%	13.0%	9.8%	8.7%	8.9%	8.8%	10.1%	12.7%	18.4%	28.9%
	Fixed	3.4%	10.3%	8.9%	8.5%	8.6%	8.7%	9.8%	10.8%	5.8%	1.0%
Partly Cloudy	Tracking	24.3%	1.8%	5.7%	8.3%	8.6%	9.0%	4.4%	12.6%	18.2%	33.7%
	Fixed	9.4%	1.3%	5.3%	8.1%	8.2%	8.8%	3.8%	11.5%	6.3%	0.7%

CONCLUSION

The efficiency of single-axis tracking and fixed solar panel was investigated. Few exceptional conclusions can be drawn in this study as follow:

i. Single-axis tracking panel is more efficient than fixed panel only in premeridian and postmeridian.
ii. At noontime or midday, both panels were producing comparable equal amount of power output.
iii. Single-axis tracking produces higher power output than fixed panel throughout the day which means it is utilizing the most of available solar radiation effectively and this will reduce payback period for the initial investment cost of this technology.

An experimental investigation with double-axis tracking system compared to single-axis tracking system should be considered in future work in this part Malaysia.

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Carbon Capture Storage Planning and Management

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Abstract

Carbon capture and storage (CCS) is considered to be a vital technology to mitigate carbon dioxide (CO_2) emissions from stationary sources such as power plants by isolating CO_2 and storing it in different reservoirs. However, retrofitting power plant with carbon capture causes major increment in unit power cost as well as parasitic power loss in the plant. In this work, a new graphical method for retrofitting power plant is proposed based on process graph (P-graph) optimisation. Illustrative case study is solved to demonstrate the implementation of P-graph. The P-graph approach for planning carbon capture retrofit can be further developed, by further development of the P-graph framework. Apart from that, related software (PNS Studio) can be further developed to solve problems with more complexity. Further work should focus on source-sink matching approach to plan for storage of carbon using P-graph, based on CO_2 emissions, injectivity limits, sink capacity and sink availability. In such planning, decisions pertaining to explore new sinks may be required. Further from that, piping size and pumping cost may be considered for detailed analysis. With the use of graphical approach, planning of carbon capture retrofit for power generation can be easily understood and efficiently solved.

Keywords

Carbon capture storage, process graph, planning, greenhouse gases emissions, power plant, optimisation

1. Introduction

Global carbon dioxide (CO_2) emissions are now major issues to the society and power generation from fossil fuels (coal, oil and natural gas) contributes to a significant portion of them. Fossil fuels currently supply more than 85% of the energy used worldwide due to their low cost, availability, existing reliable technology for energy production, and energy density (Figueroa et al., 2008). In order to reduce the climate change impacts, efficiency improvement on current technologies, fuels substitution and employment of low-carbon energy for cleaner electricity generation have been observed lately (Weisser, 2007; Varun et al., 2009). However, if there is no mature alternative technologies to fossil fuels, they will still remain as major contributor to the world's overall power generation mix in the near future (Quadrelli and Peterson, 2007). In fact, it is impractical to shut down existing fossil fuel power plant for purely environmental reason. Furthermore, fossil fuel power plant is better in terms of reliability and availability which delay the introduction of renewable energy sources such as solar, wind and hydro. Although nuclear power is now well known as an alternative to fossil fuels, but it has recently raised worldwide concerns on environmental and safety issues after several major accidents like the Chernobyl disaster in Russia, the Three Mile Island accident in U.S. and the Fukushima disaster in Japan (Sheu, 2008). These factors contribute to the requirement of retrofitting existing plant with carbon capture storage (CCS) technology in order to mitigate climate change by reducing industrial greenhouse gas emissions. Current CCS technologies include oxy-fuel combustion (OFC), pre-combustion using integrated gasification combined cycles or post combustion captures via flue gas scrubbing (FGS) (Buhre et al., 2005; Wall, 2007; Yang et al., 2008; Steeneveldt et al., 2006). 80 to 90% of carbon from power plant exhaust gases can be captured using these technologies and subsequently, compressed for secure storage in various geological formations, such as depleted oil or gas reservoirs, inaccessible coal seams, saline aquifers and other geological structures.

However, CCS is currently subjected to many uncertainties inherent in unproven technologies, particularly with regard to the reliability of long-term CO_2 storage in various sink. Efforts still have to be done to make CCS commercially viable and acceptable by the end of the decade (Davison et al., 2001; Pires et al., 2011; Pękala et al., 2010; Wall, 2007; Yang et al., 2008; Riahi et al., 2004). Retrofitting power plant with CCS now also has some major issues, one of which is the energy consumption of additional equipment. When plants are retrofitted for CO_2 capture and compression, power output of retrofitted plant is 15-20% lower than baseline level, while capital cost for plants with CCS will be 25-50% higher than that of baseline plants (Wall, 2007). Subsequently, this causes a drop in plant thermal efficiency of 5-10% and this amount of power loss is a huge component affecting costs (Jenni et al., 2013). To compensate the power loss, electricity needs to be generated from new plants in order to maintain the grid-wide power output prior to CCS deployment, which ultimately contributes to increment of costs also. Otherwise, it will result in rising of CO_2 emissions or cause power shortages, thus proper planning of CCS in power generation sector is required.

On the other hand, design of CO_2 transportation infrastructure is now recognised as an important prerequisite to successful CCS commercialisation, in order to match stream sources with appropriate sinks (Brunsvold et al., 2011). CO_2 storage is generally not in the same place where it is captured. It will be transported either done by pipeline, ship or tanker trucks, depending on the distance between the source and sink. Underground pipelines are considered to be the most cost-effective and reliable, when the volume of CO_2 to be transported is large (McCoy and Rubin, 2008; Haugen et al., 2009). Sharing of pipeline between several industrial regions allows the great emission reductions at a lower cost relatively. However, pipeline construction entails significant capital cost to the industry. Accounting for that, Turk et al. (1987) proposed the very first model to allocate CO_2 to depleted oil reservoirs for enhanced oil recovery (EOR) using pure integer linear programming (ILP). Benson and Odgen (2002) also developed a non linear programming (NLP) model similar to that of Turk et al. (1987) to design minimum cost pipeline network.

Accounting for issues above, MARKAL optimisation model has been used to demonstrate analysis of CCS systems (van den Broek et al., 2008). Life cycle assessment is also used to study trade-offs between environmental aspect and others after implementation of CCS systems (Koornneef et al., 2008). However, there are significant uncertainties with respect to economics of CCS systems and technical uncertainties in CO_2 life cycle (Hansson and Bryngelsson, 2009). Following that, systematic approaches such as *pinch analysis* (Tan et al., 2009; Shenoy and Shenoy, 2012) and *mathematical programming* (MP) (Tan et al., 2010; Pękala et al., 2010) have been developed to plan CCS deployment, at the same time minimising its energy penalties. An integration of CCS within a larger energy planning framework is also demonstrated by Koo et al. (2011). A graphical pinch diagram is proposed to match multiple CO_2 sources and storage sites or sink with a predefined geographical region (Tan et al., 2012c; Diamante et al., 2013). Continuing from pinch analysis approach, graphical approach with carbon storage composite curve (CSCC) is developed for use in selection and allocation of CO_2 storage capacity with power plants that implement carbon capture. This approach provides planning insights on degree of excess CO_2 storage capacity available to support CCS deployment in geographic region. However, further detailed assessment is still required with respect to timing, resources, project economics and environment factor (Ooi et al., 2012). As compared to MP, graphical pinch analysis approach had proven to be an effective technique due to its graphical displays which provide decision-makers with better insights for problem analysis (Foo, 2013). Useful insights and performance targets to facilitate the subsequent detailed design stage can be obtained by using this approach (Tan et al., 2009). However, there is limitation to this approach where it only accounts for relatively simple problems with highly aggregated energy sources and demands, and the constraints encountered in detailed planning cannot be included (Tan et al., 2009). Geographical distances, and hence pipeline costs between various sources and sink are also neglected (Tan et al., 2012c). Pinch approaches suffered from inherent simplifications and lower expandability when compared to MP (Tan et al., 2012c; Tan et al., 2009). Apart from that, no multiple quality measures and special conditions such as technological incompatibilities are allowed in pinch approach (Pękala et al., 2010).

Thus, to address factors mentioned above, several works based on MP were developed recently such as automated targeting (Foo et al., 2010), super structural (Pękala et al., 2010) and crisp and fuzzy integer programming models (Tan et al., 2010). Linear Programming (LP) and Mixed Integer Linear Programming (MILP) models were developed (Foo et al., 2010; Pękala et al., 2010; Tan et al., 2010) where CCS retrofit was performed for carbon-constrained energy planning. MP is preferable when detailed planning scenarios are encountered. MP also provides an opportunity to integrate more complex, case-specific goal functions especially to handle the deployment of CCS retrofit with concern for cost-effectiveness (Tan et al., 2013). However, due to lack of graphical display to ease user interpretation, the human decision maker process will be tougher.

As mentioned, the planning of CCS retrofit has been carried out via MP or pinch analysis conventionally. There is no work reported for planning CCS systems using the graphical optimisation model, which is known as Process Network Sysntheis (PNS). PNS is a methodology based on *process graph* (P-graph). User defines only the inputs and outputs for important operating units into PNS Studio (PNS Studio, 2012), which is software specially developed based on PNS methodology. This makes the methodology and software user friendly. P-graph is more powerful which results in faster solutions to extensive optimisation problems in regards to the reduction of search space. P-graph framework was first introduced by Friedler et al. (1992) for synthesis of process system. It was then extended for molecular design based on group contribution method (Friedler et al., 1998), reaction pathway synthesis (Seo et al., 2001) and identify candidate mechanisms for derivation of rate law (Fan et al., 2002), synthesis of separation network (Kovacs et al., 1999; Heckl et al., 2003), azeotropic distillation systems sequencing (Feng et al., 2000; Bertok et al., 2001), heat exchanger network synthesis (Nagy et al., 2001) and biomass networks synthesis (Lam et al., 2012). This is then developed for reduction of carbon emissions involving combined heat and power cycle (Varbanov and Friedler, 2008), optimal design of industrial processes (Friedler 2010), synthesis for renewable resources (Halasz et al., 2005), and optimizing regional energy supply chain (Lam et al., 2010). Based on the previous works on P-graph, this approach can be extended further to solve CCS planning.

This paper presents the planning for optimal retrofit of power plants at sectoral, regional or national level using P-graph approach. First, a formal problem statement is given in the section that follows. A brief explanation on methodology used in this paper is discussed. An initial linear programming (LP) model is developed for better understanding. A case study from previous CCS work is solved using P-graph approach and results are validated to demonstrate the compatibility of P-graph in CCS planning. Furthermore, different parameters are used to illustrate the potential future scenarios in CCS planning.

2. Problem Statement

The problem to be addressed is stated as follows:

- The main objective is to minimise the carbon footprint of the entire sector, by selecting the power plants to be retrofitted and by identifying the best technique for retrofitting a given plant using a well established process graph (p-graph) technique, while the incremental cost of electricity is kept within a specified limit.

- The CCS system is assumed to be comprised of m CO_2 sources, each producing a stream of fixed quantity (e.g. flowrate) and quality (e.g. concentration) and the choice of carbon capture technology, j (j = 1, 2, …, t) for each plant is limited to a maximum of one and each CCS technologies, n has a fixed efficiency.

- Each CO_2 source i (i = 1, 2, …, m) is characterised by fixed captured CO_2 flowrate that corresponds to the maximum removal from the plant's flue gas.

- Any given CO_2 sources may be connected to only one CCS technology. However, a CCS technology may be linked to multiple CO_2 sources. The allocated CO_2 source to the CCS technology is subjected to the maximum availability of the source.

- Due to large uncertainties associated with cost estimation, an aggregate cost limit is used with parameters based simply on relative costs of power from unmodified, retrofitted and new power plants.

- A superstructure representation of such a network is presented in Figure 1, showing all possible connections between the sources-technology-sinks.

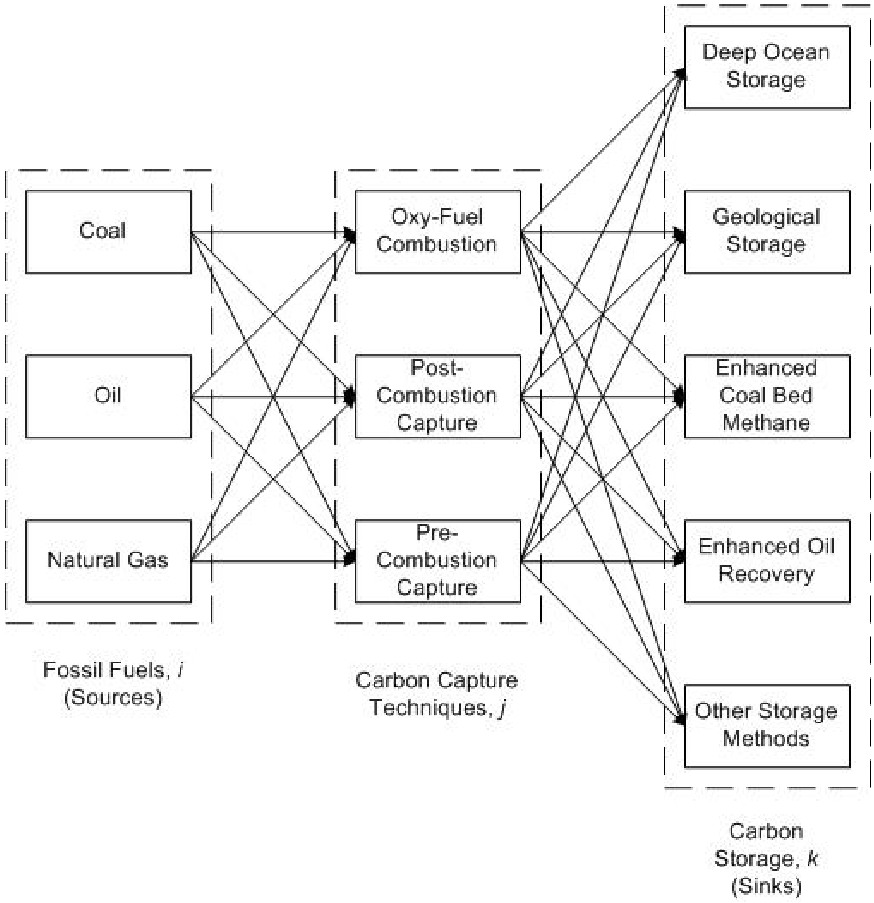

Figure 1: Schematic representation of CCS options (Tan et al., 2010)

3. Methodology

In this work, P-graph is applied for planning optimal retrofit of power plants at sectoral, regional or national level. The concept of P-graph is briefly explained in this section. P-graph is a bipartite graph for umabiguous representation of processing networks. There are two types of vertices, horizontal bars representing operating units and the other (solid circles) representing material or energy streams, vertices are connected by directed arcs (Friedler et al., 1992). A simple conventional and P-graph representation of an operating unit is shown as Figure 2.

There are several combinatorial instruments associated with it (Varbanov and Friedler, 2008; Lam et al., 2012). First, the axioms and theorems are to ensure representation unabiguity and consistencies of the resulting super-structures and solution networks. The other instruments are the three main algorithms which include superstructure construction – maximal structure generation (MSG), superstructure traversal and the generation of combinatorially feasible network structures – solution-structure generation (SSG), and superstructure optimisation branch and bound algorithm – accelerated branch and bound (ABB) (Lam et al., 2012; Peters et al., 2004).

In order to plan of CCS using P-graph, it requires that data be specified for power plants within a region (i.e., rated capacities and emission factors) and carbon capture technologies (i.e., removal ratios and power losses). Data will be input into PNS Studio (PNS Studio, 2012), which is software doing optimisation based on P-graph methodology, the graph can be generated and software can select power plants for retrofitting with appropriate carbon capture technology to fulfill carbon footprint reduction targets, cost limits and power losses. The methodology is illustrated by case studies that follow.

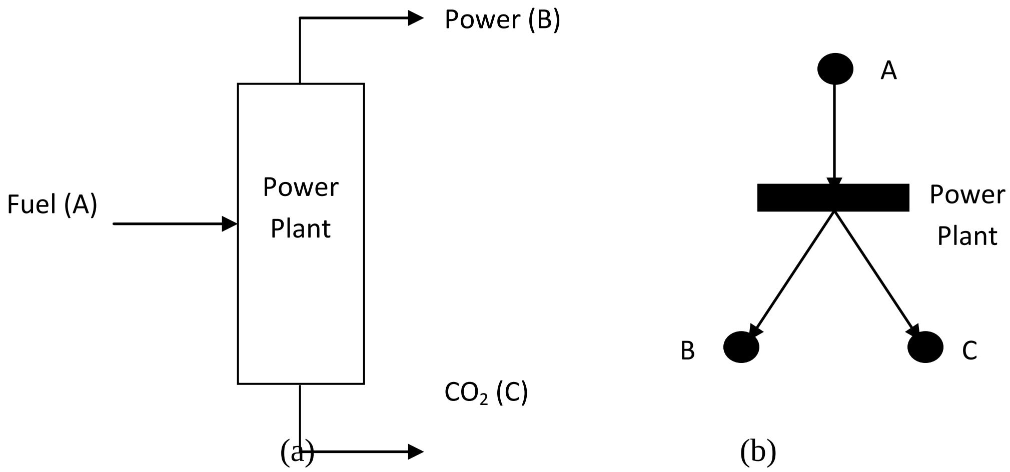

Figure 2: Conventional and P-graph representations of a power plant

4. CCS Model with P-Graph Representation

The model follows three parts of the network's maximum structure shown in Figure 6, starting from power targeted by each plant and corresponding costs, followed by technologies, and finally the total final power output and corresponding costs. For the first part, power targeted for each plant is connected to different retrofitting technology. At the same time, total power cost will be proportional to the power generated and cost changes according to the technology matched. CO_2 released will be determined by power targeted for each power plant and fuel used. Relationships of power generated and power cost to the retrofitting technology are shown in Equations (1) and (2) below; both equations are showing simple balance of power and power cost. The graphical representation of these relationships is shown in Figure 3.

$$P_i = \sum_{\mathrm{j}} \mathrm{P_{ij}} \quad \forall \mathrm{j} \tag{1}$$

$$C_i = \sum_{\mathrm{j}} \mathrm{P_{ij}c} \quad \forall \mathrm{j} \tag{2}$$

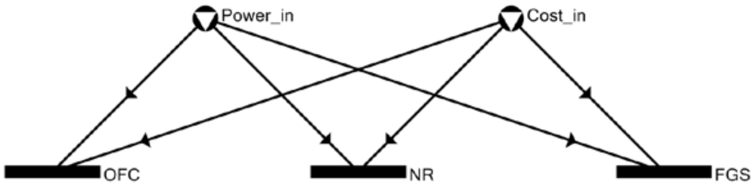

Figure 3: P-graph representations of the relationship between power from each plant and retrofitting technologies

Equations (3) and (4) show the second part of these relationships, which is between power generated with the retrofitting technology and total power cost with the retrofitting technology. For both equations, the first terms in the equations give the power and cost after going through a carbon capture technology while second term gives the power or cost resulted from a new compensatory plant.

$$P_j = \mathrm{P_{ij}x_{ij}}\left(1 - \mathrm{L_j}\right) + \mathrm{P_{ij}x_{ij}L_j} \tag{3}$$

$$C_j = P_{ij}x_{ij}(1 - L_j)A_j + P_{ij}x_{ij}L_jB \tag{4}$$

The choice of CCS technologies for each plant is limited to maximum of one. When a retrofitting technology is chosen, x_{ij} is denoted as one, or zero otherwise.

$$\sum_{j} x_{ij} \leq 1 \quad \forall j \tag{5}$$

$$x_{ij} \in \{0,1\} \quad \forall i, j \tag{6}$$

When the plant is chosen to be retrofitted, power loss (L_j) follows the value given in each case study. If no modification of power plant is chosen, L_j is equal to zero. Cost coefficients (A_j and B) are dimensionless, and give the relative cost of electricity in comparison with the baseline cost. The relationship is represented using P-graph as shown in Figure 4.

The final output is equal to the summation of all outputs from all technologies, as shown in the Equations (7) and (8) below. Figure 5 shows the P-graph representation of these relationships.

$$P_{total} = \sum_{j} P_j \quad \forall j \tag{7}$$

$$C_{total} = \sum_{j} C_j \quad \forall j \tag{8}$$

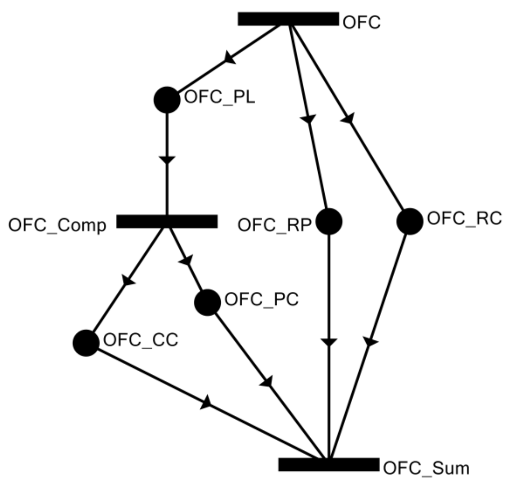

Figure 4: P-graph representations of the relationship between input to retrofitting technology and output from retrofitting technology

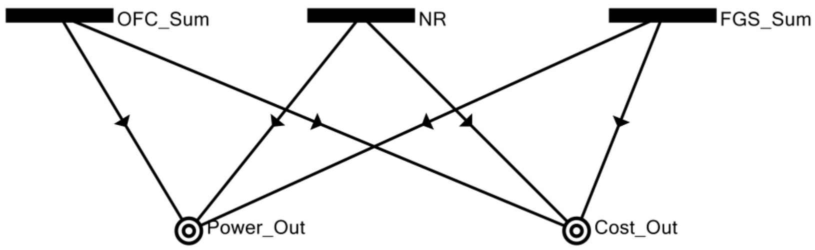

Figure 5: P-graph representations of the relationship between output from retrofitting technology and total final power and cost

Combining all three parts, Figure 6 shows the overall structure of the problem using P-graph approach which consists of all possible solutions, namely the maximum structure.

The objective function of all problems studied in this paper is to maximise the reduction of total carbon emissions:

$$\max \sum_{i} P_i F_i \left[\sum_{j} RR_j x_{ij} \right] - D \left[\sum_{i} P_i \left(\sum_{j} L_j x_{ij} \right) \right] \quad (9)$$

The first term gives the total reduction in emissions from carbon capture retrofitting, while the second term gives the additional emissions from new plants that are added to compensate the parasitic power losses. Hence, the summation of two terms gives the emissions reduction relative to base level.

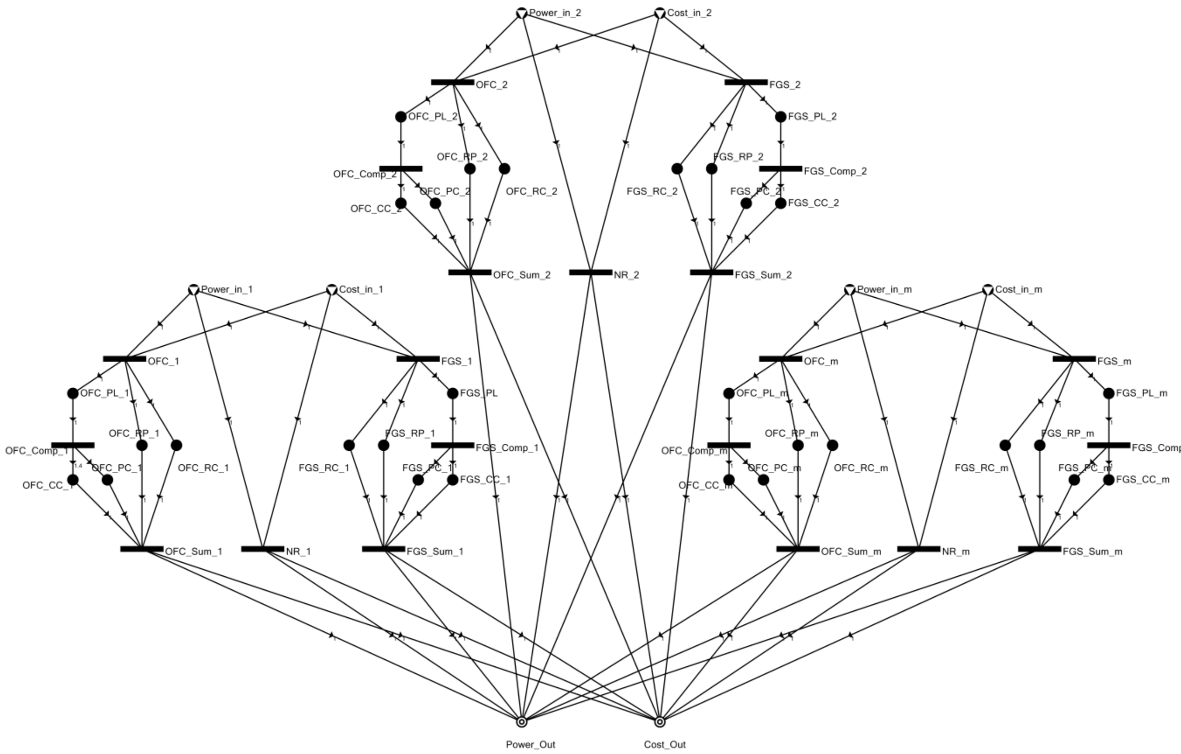

Figure 6: P-graph representations of the maximum structure of problem

5. Base Case

This case study is adapted from Tan et al. (2010). As shown in Table 1, six power plants are to be considered for CCS retrofit. Each of these plants has specified capacities and emissions factors based on its fuel. The total power generated in this region is 2250 MW and CO_2 produced corresponding to this power generation is 1715 t/h; this is equivalent to average carbon footprint of 0.762 t/MWh. In this case study, two carbon capture technologies, which are flue gas scrubbing (FGS) and oxy-fuel combustion (OFC), are considered as choices for reducing carbon emission. There is one technological compatibility restriction assumed here, plant 6 is not suitable for OFC retrofit. The removal ratio (RR_j) and relative power loss (L_j) of FGS are 0.8 and 0.2; while for OFC are 0.9 and 0.25 respectively. These values are based on assumption in Tan et al. (2010). Power loss results from retrofitting will be compensated, and emission factor of compensatory plant (D) is taken as 0.1 t CO_2/MWh.

For economic analysis, it is assumed that electricity produced in the retrofitted plants cost 60% more expensive than that from unmodified plants. As for the electricity generated from compensatory plant, each unit costs 40% more expensive than the base cost. Hence, the relative cost coefficients (A_1, A_2, A_3 and B) used for Equation (4) are given as 1, 1.6, 1.6 and 1.4 The main objective is to minimise carbon footprint without increasing the overall electricity cost by more than 30% than the base cost.

Table 1: Plant data for Base Case

Plant	Fuel	Emission factor (t CO_2/MWh)	Power (MW)	Emission (t CO_2/h)
1	Coal	1	600	600
2	Coal	1	500	500
3	Natural gas	0.5	250	125
4	Natural gas	0.5	300	150
5	Natural gas	0.5	400	200
6	Oil	0.7	200	140
Total			2250	1715

5.1 Identification of Materials in the P-graph Method

After collecting all relevant data, the specifications for all inputs to and outputs from the system should be produced, together with those for intermediate materials. Table 2 shows the summary of all materials and units that will be involved in P-graph calculation according to Figure 6.

Table 2: Materials and units for P-graph

Symbols	P-graph classification	Description
$Power\_in_i$	Input	Power produced from each plant
$Cost\_in_i$	Input	Cost corresponding to power generated from each plant
OFC_RP_i	Intermediate	Power output from OFC from each plant
OFC_RC_i	Intermediate	Cost output from OFC from each plant
OFC_PL_i	Intermediate	Power loss due to OFC for each plant
OFC_PC_i	Intermediate	Power from compensatory plant for OFC in each plant
OFC_CC_i	Intermediate	Cost from compensatory plant for OFC in each plant
FGS_RP_i	Intermediate	Power output from FGS from each plant
FGS_RC_i	Intermediate	Cost output from FGS from each plant
FGS_PL_i	Intermediate	Power loss due to FGS for each plant
FGS_PC_i	Intermediate	Power from compensatory plant for FGS in each plant
FGS_CC_i	Intermediate	Cost from compensatory plant for FGS in each plant
Power	Output	Total power generated from all plants
Cost	Output	Total cost correspond to total power generated
OFC_i	Operating Unit	Oxy-fuel combustion unit
NR_i	Operating Unit	No modification
FGS_i	Operating Unit	Flue gas scrubbing unit
OFC_Comp_i	Operating Unit	Compensatory plant for plant using OFC

FGS_Comp_i	Operating Unit	Compensatory plant for plant using FGS
OFC_Sum_i	Operating Unit	Summation of output for plant using OFC
FGS_Sum_i	Operating Unit	Summation of output for plant using FGS

5.2 Identification of Operating Units in the P-graph Method

This step produces a set of candidate operating units, which is able to transform inputs to desired outputs, through intermediates (Varbanov and Friedler, 2008). These operating units chosen will be interconnection between all materials. Units that are involved in this case are shown in Table 2.

Input the available data into PNS Studio accordingly to Figure 6 and solve the case study using algorithm SSG and LP, an optimal result shows that Plant 1 and 2 requires retrofitting with OFC option, while the rest remaining unmodified. The summary of the results is shown in Table 3. Final carbon emission after retrofitting is 752.5 t/h as reported in Table 3. Dividing this amount by the power generated, which is 2250 MW, yields the final carbon footprint of 0.334 t/MWh. This indicates the greatest possible reduction of carbon footprint is about 0.428 t/MWh, which correspond to 56.12% decrement from baseline level of 0.762 t/MWh. The resulting electricity cost is 26.89% more expensive than the baseline cost. The final contributions to the total power output are 1150 MW (51.1%) from unmodified plants, 825 MW (36.7%) from retrofitted plants and 275 MW (12.2%) from new compensatory plant. The overall results are further summarised in the second column of Table 4. These results are confirmed and proven by mathematical model previously generated by Tan et al. (2010).

Table 3: Power sector data after CC retrofit in Base Case.

Plant	CC Technique	Final Power Output (MW)	Final Carbon Emissions (t CO_2/h)	Increase in cost per unit of power (%)
1	OFC	450	60	60
2	OFC	375	50	60
3	None	250	125	0
4	None	300	150	0
5	None	400	200	0
6	None	200	140	0
Compensatory	None	275	27.5	40
Total		2250	752.5	26.9

Table 4: Key results for Base Case and Scenario 1 – 3

Parameter	Base Case	Scenario 1	Scenario 2	Scenario 3
Final carbon footprint (t/MWh)	0.334	0.278	0.295	0.308
Relative reduction (%)	56.12	63.56	59.90	59.65
Grid relative power cost	1.269	1.296	1.296	1.274
Power from unmodified plants (MW)	1150	850	1200	1150
Power from retrofitted plants (MW)	825	1050	1050	880
Power from new plants (MW)	275	350	350	220

Figure 7 shows an overall optimum solution for retrofitting of all six power plants in this case study using graphical representation. For example, it is understood from the figure that Power Plant 1 will be retrofitted using OFC option. Power produced from the plant will be reduced and a compensatory power plant is built to compensate the loss with carbon emission of 1 t CO_2/MWh.

Same option is chosen for Power Plant 2 while the others remaining unmodified. These outputs will be sum as the final power output and total power cost.

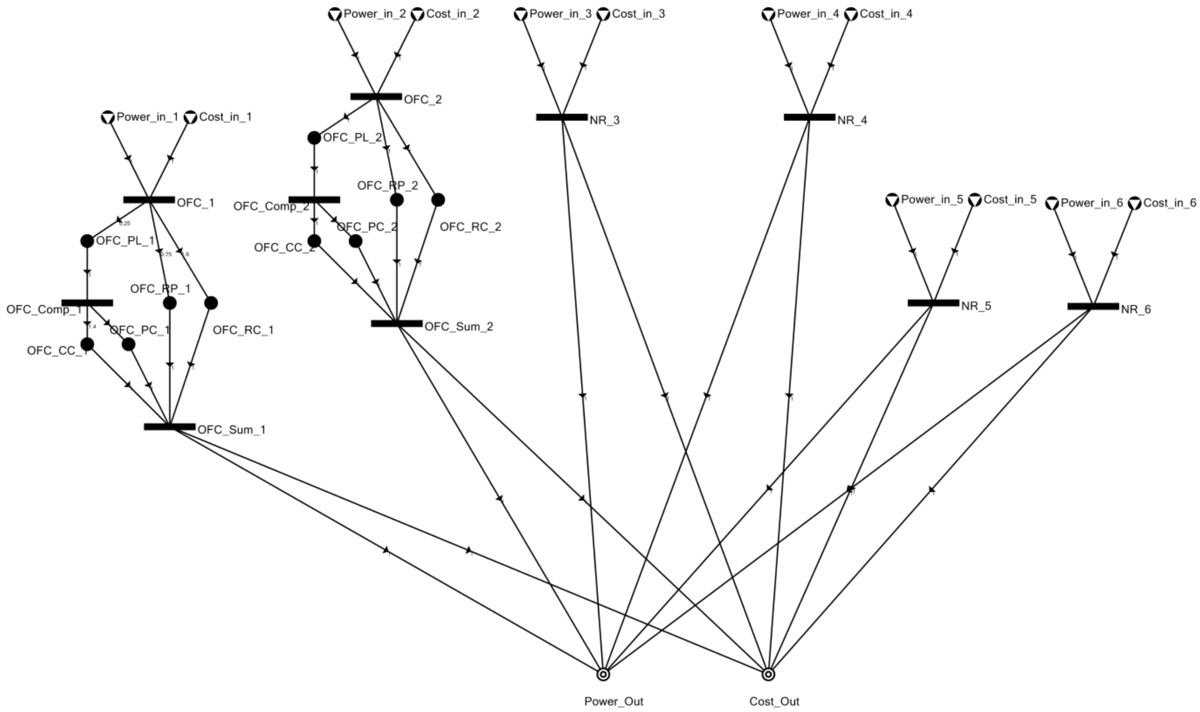

Figure 7: Graphical P-graph solution for optimum retrofitting of power plants in Base Case

6. Scenario 1

Assuming Base Case shows the current power generation in realistic, there are many possible scenarios that may occur in the future. In this first scenario, it is assumed that all power plants implementing carbon capture storage have subsidies from government, thus reducing the power cost from retrofitted power plants. It was studied that major policy initiatives are required for reducing the carbon emissions globally and subsidies to low-carbon technologies such as CCS is an important element of future climate policies around the world (Aune et al., 2009).

This scenario makes use of the same data as the previous one, except with changes in the increment in unit cost of electricity produced in retrofitted plant. The initial assumption is electricity produced in retrofitted plants costs 60% more than that produced by unmodified plants, it is now costs only 50% more expensive, 10% increment is subsidised by the government. Having financial support from government, it is expected that more power plants able to have carbon capture technology installed, and hence lower total carbon emission.

By inputting the data into PNS Studio solving using algorithm SSG and LP, an optimal result shows three plants, which are Plants 1, 2 and 4, require retrofitting with OFC technology while keeping the others unchanged. Table 5 shows the results after the change in cost increment was made. Summarised overall results for the entire power sector are given in the third column in Table 4. The final carbon footprint of resulting electricity mix is 0.2778 t CO_2/MWh, which is 63.56% lower than the baseline level. The unit cost of electricity is 29.56% more expensive than baseline cost. The final contributions to power mix are 850 MW (37.8%) from unmodified plants, 1050 MW (46.7%) from retrofitted plants, and 350 MW (15.5%) from compensatory plants. The overall optimum solution to this scenario is shown using P-graph representation in Figure 8 below.

As compared to Base Case, this results in much higher reduction in carbon emissions and slightly higher unit cost of power. It shows one extra power plant can install OFC compared to Base Case without compromising the economic limit set. It is obvious that having subsidies support, the power sector is able to have more plants retrofitted and reduce emission of greenhouse gases. This result, when compared with that of Base Case, clearly shows how sensitive are the carbon footprint reduction to the cost increment from retrofitting a power plant.

Table 5: Power sector data after CC retrofit in Scenario 1

Plant	CC Technique	Final Power Output (MW)	Final Carbon Emissions (t CO_2/h)	Increase in cost per unit of power (%)
1	OFC	450	60	50
2	OFC	375	50	50
3	None	250	125	0
4	OFC	225	15	50
5	None	400	200	0
6	None	200	140	0
Compensatory	None	350	35	40
Total		2250	625	29.6

7. Scenario 2

In Base Case and Scenario 1, the power demand is assumed to be same and so does the power output from each plant. Power demand is estimated to be about 30% higher in the 30 years time, as economic output more than doubles and prosperity expands across a world with population growing rapidly (ExxonMobil, 2012). Therefore power output of some power plants shall be increased to meet the demand. In this scenario, power output of Plants 3, 4 and 6 are increased by 100 MW, 150 MW and 100 MW respectively, these changes made are shown in Table 6. Increasing the power output will increase the carbon emissions as well. The emission factors are kept constant in this scenario, thus the carbon emissions of Plants 3, 4 and 5 are now 175 t/h, 225 t/h and 210 t/h. Apart from these, the other data are remained the same as Base Case.

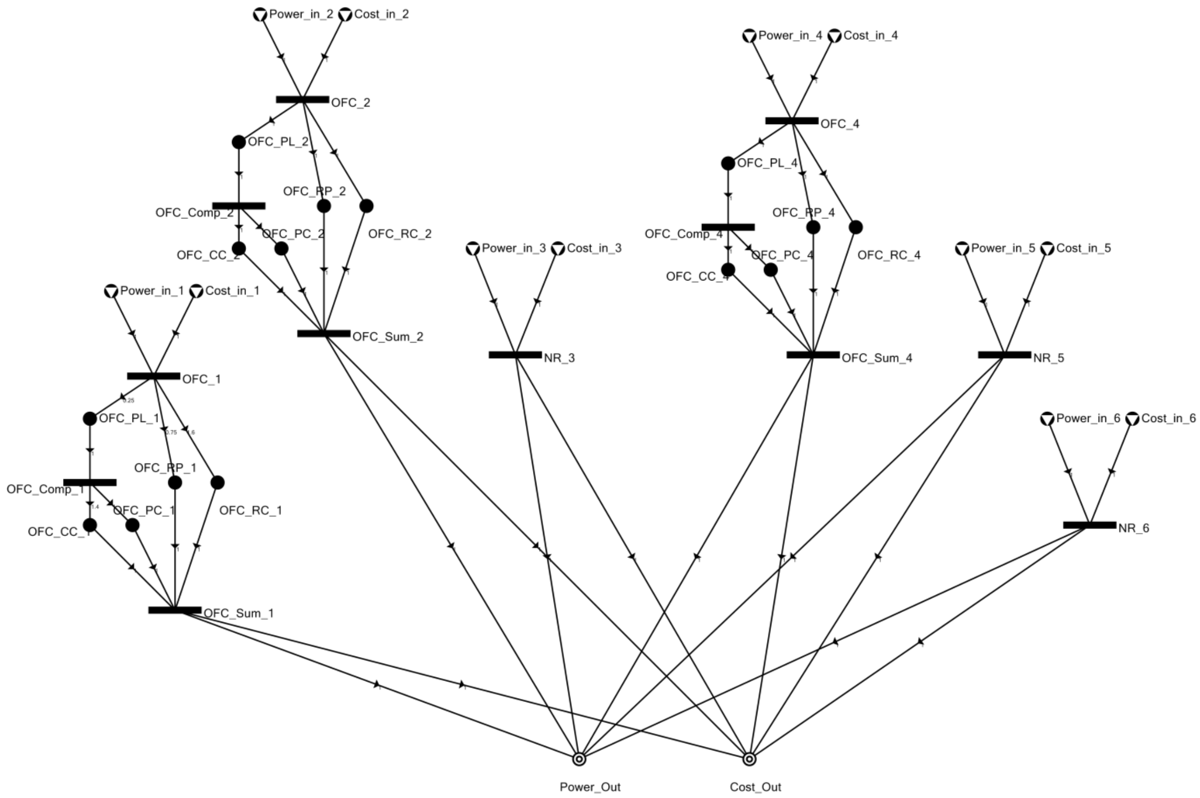

Figure 8: Graphical P-graph solution for retrofitting of power plants in Scenario 1

Same procedure as in Base Case and Scenario 1, this scenario is solved using algorithm SSG and LP in PNS Studio and the summarised results are shown in Table 7 below. The optimal solution is to retrofit Plant 1, 2 and 6 using OFC and keeping the others unmodified. The final carbon footprint is 0.2946 t/MWh, this is higher than Scenario 1 but lower than Base Case. The corresponding reduction of carbon footprint is only 59.90% of the baseline level while the cost increment is 29.62% of base cost. The carbon footprint reduction is lower than both cases studied previously and the cost increment is the highest among all cases. In this scenario, the final power mix consists of 1200 MW (46.1%), 1050 MW (40.4%) and 350 MW (13.5%) from unmodified, retrofitted and new compensatory plants. These are summarised in forth column Table 4. Figure 9 shows the graphical representation optimum solution for retrofitting power plants in this scenario.

Table 6: Plant new data for scenario 2

Plant	Fuel	New Power Output (MW)	Increment in Power (MW)	Emission (tCO_2/h)
1	Coal	600	0	600
2	Coal	500	0	500
3	NG	350	100	175
4	NG	450	150	225
5	NG	400	0	200
6	Oil	300	100	210

Table 7: Power sector data after CC retrofit in Scenario 2

Plant	CC Technique	Final Power Output (MW)	Final Carbon Emissions (t CO_2/h)	Increase in cost per unit of power (%)
1	OFC	450	60	60
2	OFC	375	50	60

3	None	350	175	0
4	None	450	225	0
5	None	400	200	0
6	OFC	225	21	60
Compensatory	None	350	35	40
Total		2600	766	29.6

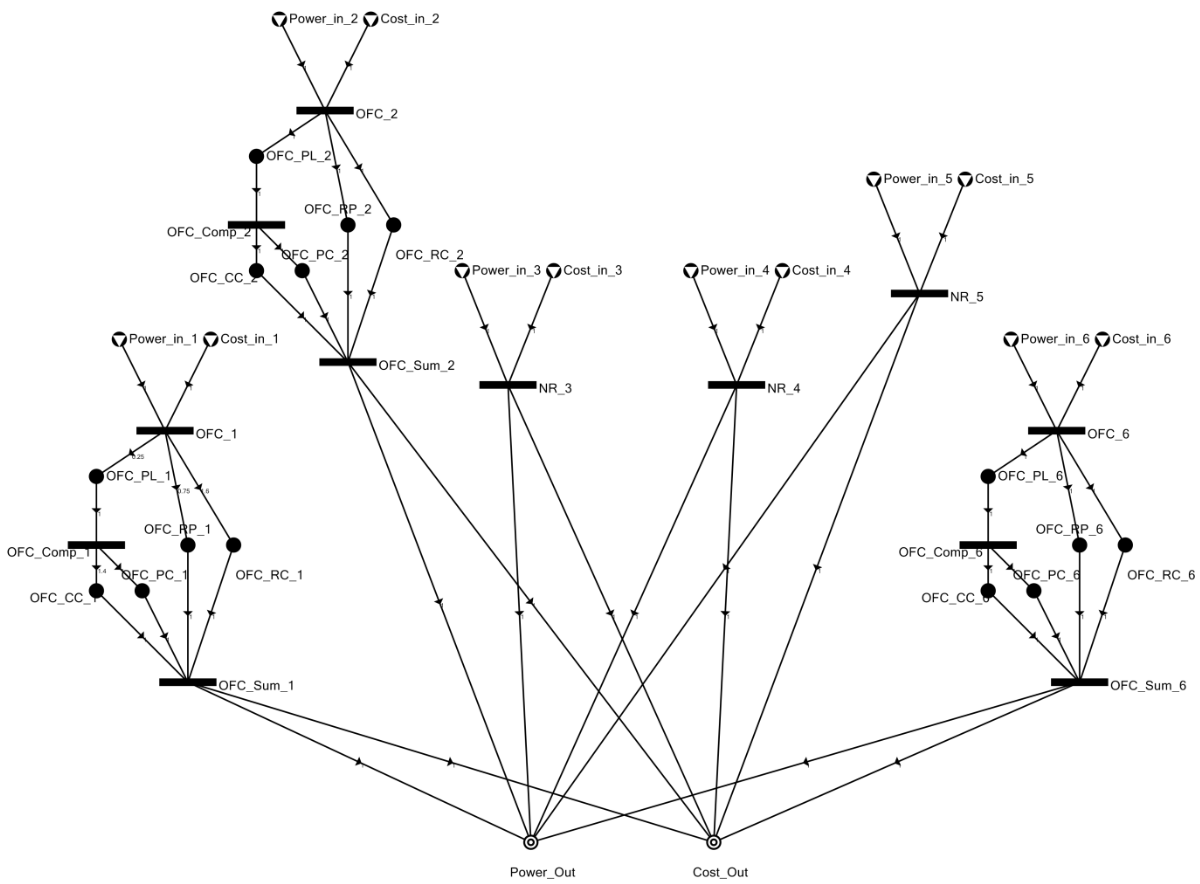

Figure 9: Graphical P-graph solution for retrofitting of power plants in Scenario 2

Compared to Base Case and Scenario 1, it shows that with increment in power demand and no changes in cost increment from retrofitted plant, the potential is as high compared to that in Scenario 1. Having higher total power output, total power cost will be higher and this should give larger cost allowance for retrofitting, thus higher potential to carry out retrofitting. However, the final relative unit power cost is relatively higher, this scenario still has higher carbon footprint than that of Scenario 1. This indicates that increment in power demand do not affect the reduction of carbon emissions as much as changes in cost from retrofitting a plant.

8. Scenario 3

Scenario 1 and Scenario 2 show effects of government subsidy support and population growth on the carbon emission of the entire power sector, but there is another possible scenario not studied which is improvement in carbon capture technology. Carbon capture technologies are now still in embryonic state and there is potential in improving them further (David and Herzog, 2000; Howells and Holger Rogner, 2012). In this scenario, it is assumed that the removal ratios of both carbon capture technologies increase while the relative power losses decrease. Same data as Base Case is used here, except for the removal ratio of both carbon capture technology. The changes made are shown in Table 8, where removal ratio for OFC and FGS are 0.95 and 0.90; while relative power losses are 0.20 and 0.10 respectively (Merkel et al., 2010; Buhre et al., 2005).

Table 8: Technology new data for scenario 3

Technology	Removal Ratio	Relative Power Losses
OFC	0.95	0.20
FGS	0.90	0.10

Following the method in all cases previously done gives optimal results shown in Table 9. The best solution is to retrofit Plants 1 and 2 using OFC technology and leave the others unchanged, which is the same result as that for Base Case. This gives the final carbon footprint of 0.3076 t/MWh and corresponds to a reduction of 59.65% from the baseline level. Final carbon footprint is lower compared to Base Case and Scenario 2 but it is higher than that of Scenario 1. The unit power cost increases by 27.4%, which is slightly higher than that of Base Case. The final power mix consists of 1150 MW (51.1%), 880 MW (39.1%) and 220 MW (9.8%) from unmodified, retrofitted and new compensatory plants as presented in fifth column in Table 4. Figure 10 shows the graphical representation of the optimum solution for this scenario.

This result shows that the further improvement of technology does not affect the result much, when compared with that in Base Case, due to only small changes can be made to carbon capture technology. While Base Case and this scenario have chosen the same plants for modification, this scenario has higher unit power cost. This indicates that improving carbon capture technology without financial support will lead to higher unit power cost with only slightly lower carbon emissions unless there is new technology which is as effective with lower capital cost.

Table 9: Power sector data after CC retrofit in Scenario 3

Plant	CC Technique	Final Power Output (MW)	Final Carbon Emissions (t CO_2/h)	Increase in cost per unit of power (%)
1	OFC	480	30	60
2	OFC	400	25	60
3	None	250	125	0
4	None	300	150	0
5	None	400	200	0
6	None	200	140	0
Compensatory	None	220	22	40
Total		2250	629	27.4

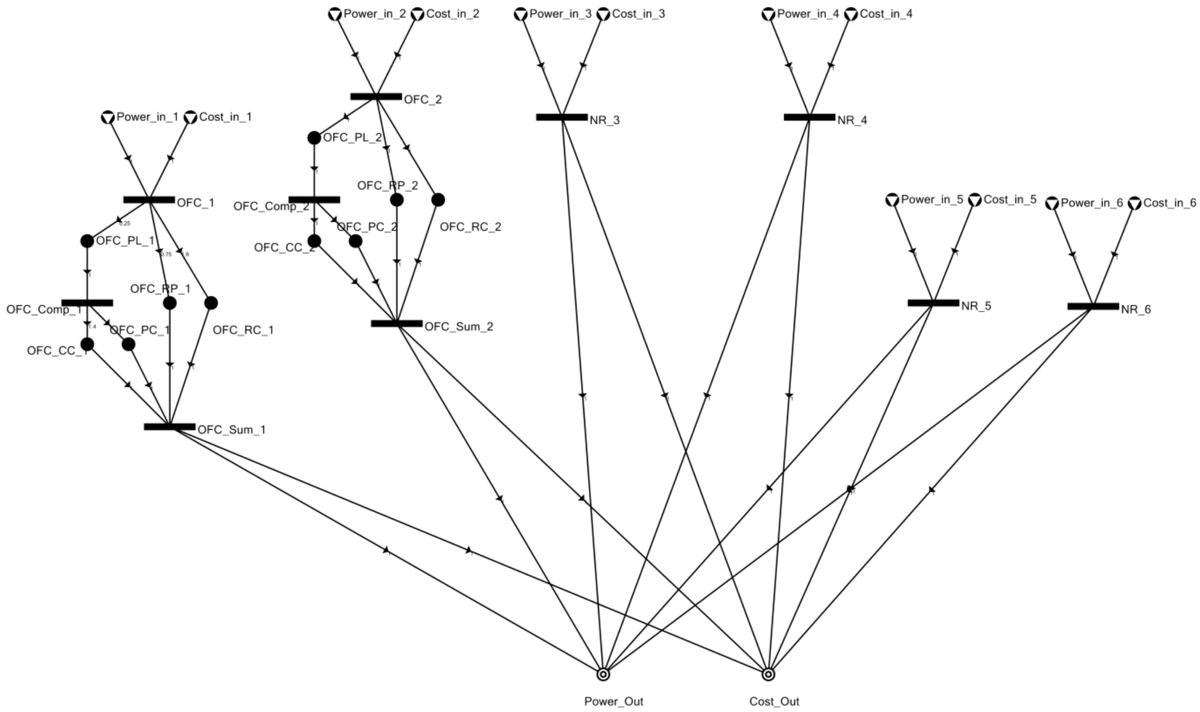

Figure 10: Graphical P-graph solution for retrofitting of power plants in Scenario 3

9. Advantages of the P-graph

P-graph has shown its advantages as a flexible optimisation tool for all case study and scenarios discussed in this paper. It has been successfully demonstrated planning of carbon capture retrofit in power generation. P-graph is very effective and efficient for analysing illustrative scenarios and conducting sensitivity analysis because users can obtain better insight of the cases analysed using graphical method (Poon, 2013; Lam et al., 2012). Apart from that, P-graph shows all possible solutions to the problem, unlike conventional mathematical programming. Having this advantage, users will be able to find solutions that are close to optimal as substitute if the optimal solution is infeasible. This will ease the decision making process on retrofitting of power plants for upper management who has limited mathematical programming background.

P-graph is very easy to be used; it can be easily implemented for different usage. Users who have limited knowledge on mathematical programming can easily learn to use P-graph as it is easier for visualisation. Besides that, no special training is required for using P-graph to do optimisation, which is appreciated by most of the users. Users only need to specify data for materials and define relationships between materials and respective units to solve a complicated optimisation problem. By specifying data correctly, P-graph can be used for multiple applications as mentioned previously in Introduction.

This graphical tool is flexible for further extension in future. There will always be extension or improvement in industries. Users only require defining the new or improved materials or units into the network, optimum solution can be obtained easily.

10.Conclusions

This paper demonstrated the extension of application of P-graph method to optimal planning of carbon capture retrofit in power generation at the sectoral, regional or national level. The relationships between integer programming models developed previously and the related P-graph representations have been demonstrated in this paper as well. One illustrative case study adapted from Tan et al. (2010) has been solved and followed by three different scenarios to demonstrate the applicability of the proposed approach. In this approach, carbon footprint reduction targets, cost limits and power losses are taken into account. By comparing results to that by Tan et al. (2010), P-graph methodology is proven to be as effective as mathematical programming. Once the optimal matching is determined, further assessment of carbon capture storage may follow. Planning carbon capture retrofit in power generation using P-graph is more user-friendly for one with no mathematical programming background, as the input of data is more convenient and easy for illustration purpose.

The P-graph approach for planning carbon capture retrofit can be further developed, by further development of the P-graph framework. Apart from that, related software (PNS Studio) can be further developed to solve problems with more complexity. Further work should focus on source-sink matching approach to plan for storage of carbon using P-graph, based on CO_2 emissions, injectivity limits, sink capacity and sink availability. In such planning, decisions pertaining to explore new sinks may be required. Further from that, piping size and pumping cost may be considered for detailed analysis.

With the use of graphical approach, planning of carbon capture retrofit for power generation can be easily understood and efficiently solved, by providing better insights for problem analysis.

Acknowledgement

This research was done with the help of Professor Raymond R. Tan from De La Salle University and Wendy Ng Pei Qin from University of Nottingham Malaysia Campus for helpful suggestions and assistance to improve the concept.

Nomenclatures

Indices

i	power plants (i = 1, 2, …, m)
j	CC technology (j = 1, 2, …, n)

Parameters

A_j	relative cost of electricity from plants retrofitted with CC technology (dimensionless)
B	relative cost of electricity from new plants to compensate for energy losses (dimensionless)
c	unit cost for power prior to retrofit ($/MW)
C_i	corresponding cost for power generated by power plants i ($/MW)
C_{ij}	corresponding cost for power related from power plants i to CC techniques j ($/MW)
C_j	corresponding cost for power output from CC techniques j ($/MW)
C_{total}	total cost corresponding to total power generated in the region ($/MW)
D	emission factor of power generation to compensate for CC energy losses (t CO_2/MWh)
L_j	relative energy loss associated with CC technology j (dimensionless)
m	number of power plants
n	number of CC techniques
P_i	power output targeted for power plants i (MWh)
P_{ij}	power related from power plants i to CC techniques j (MWh)
P_j	power output after passing through CC technique j (MWh)
P_{total}	total power output in the region (MWh)
RR_j	removal ratio of CC technique j (dimensionless)

Variables

x_{ij} binary variable denoting decision to use CC technology j in plant i

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Appendix

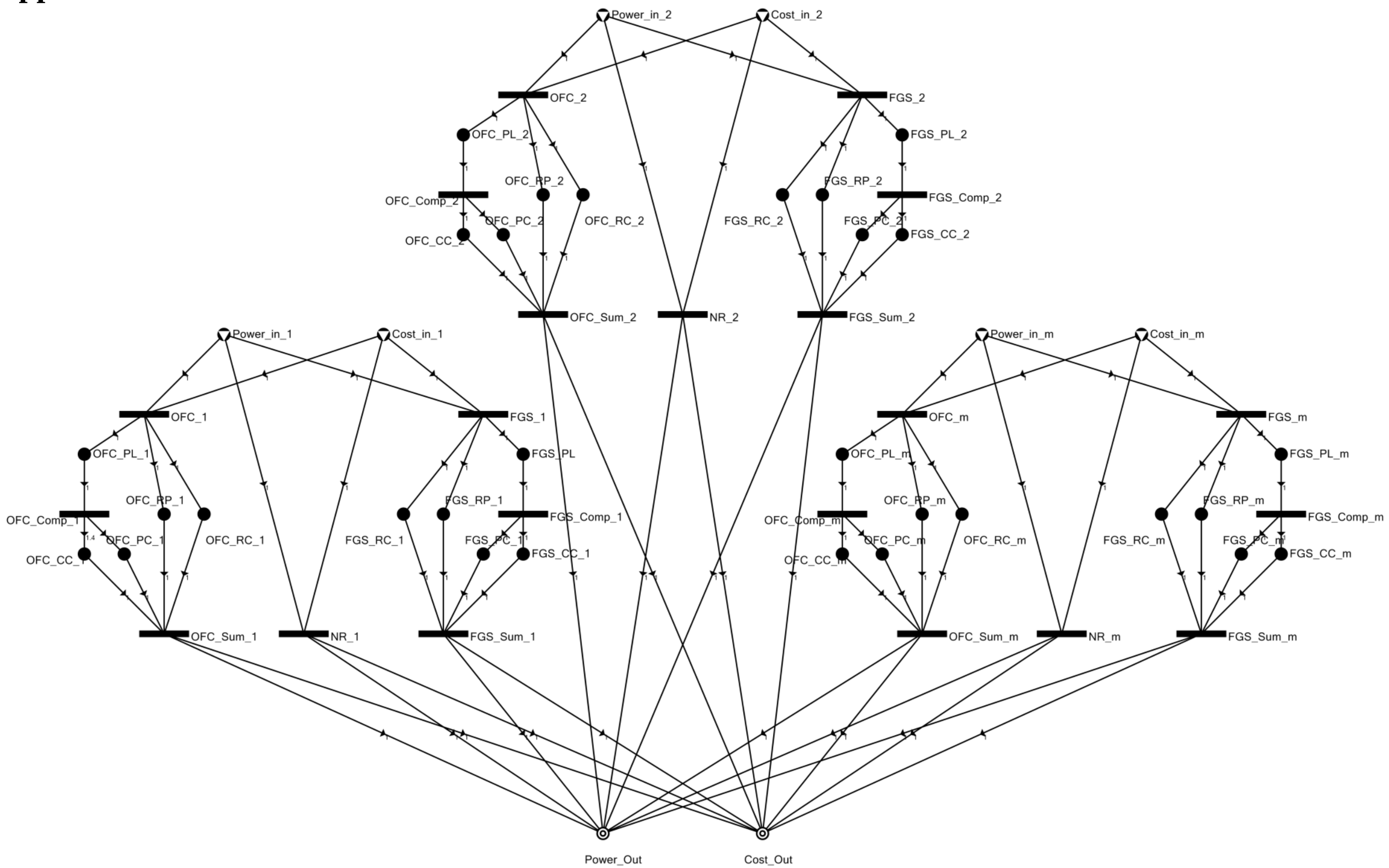

Figure 11: Enlarged view of P-graph representations of the maximum structure of problem

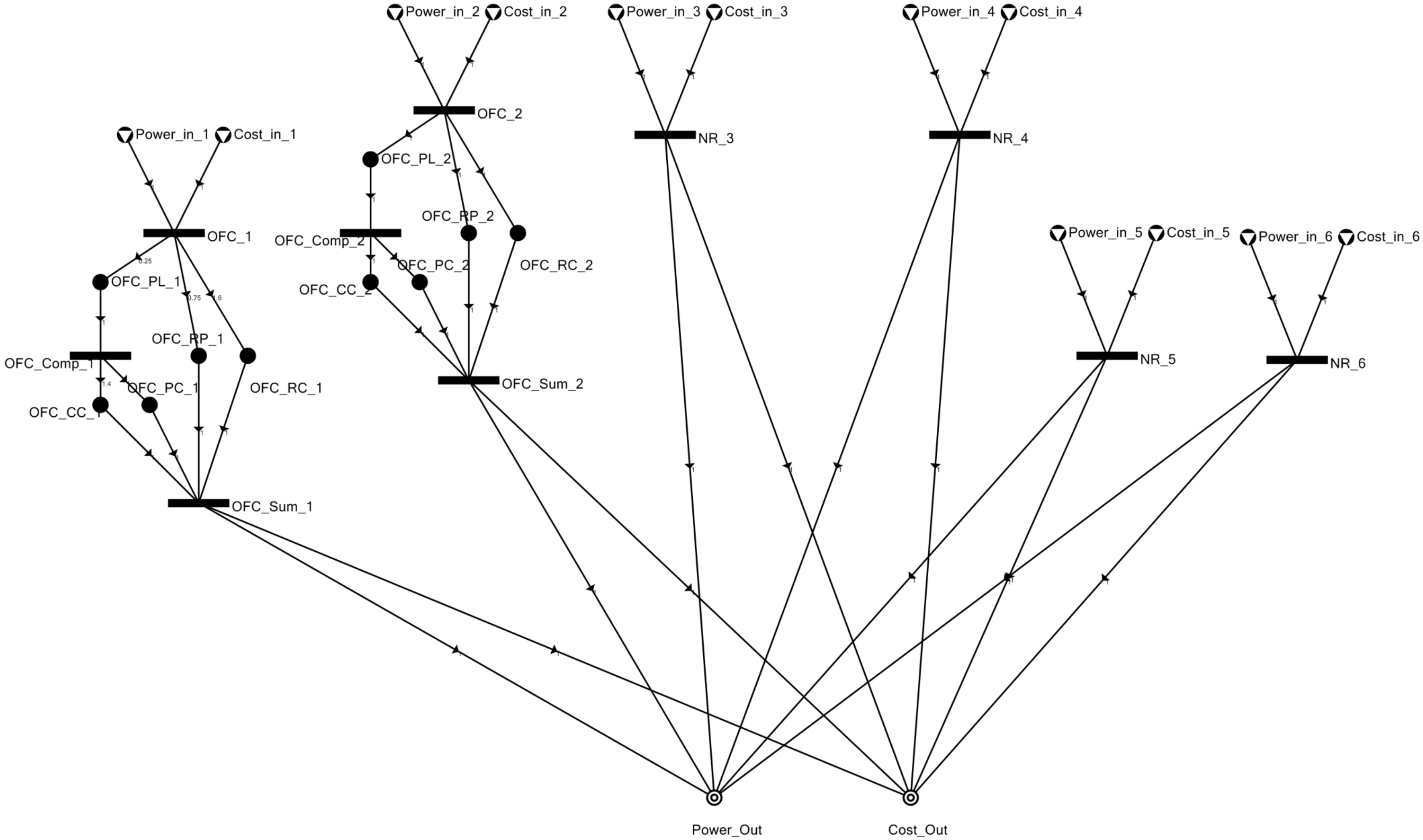

Figure 12: Enlarged view of graphical P-graph solution for optimum retrofitting of power plants in Base Case

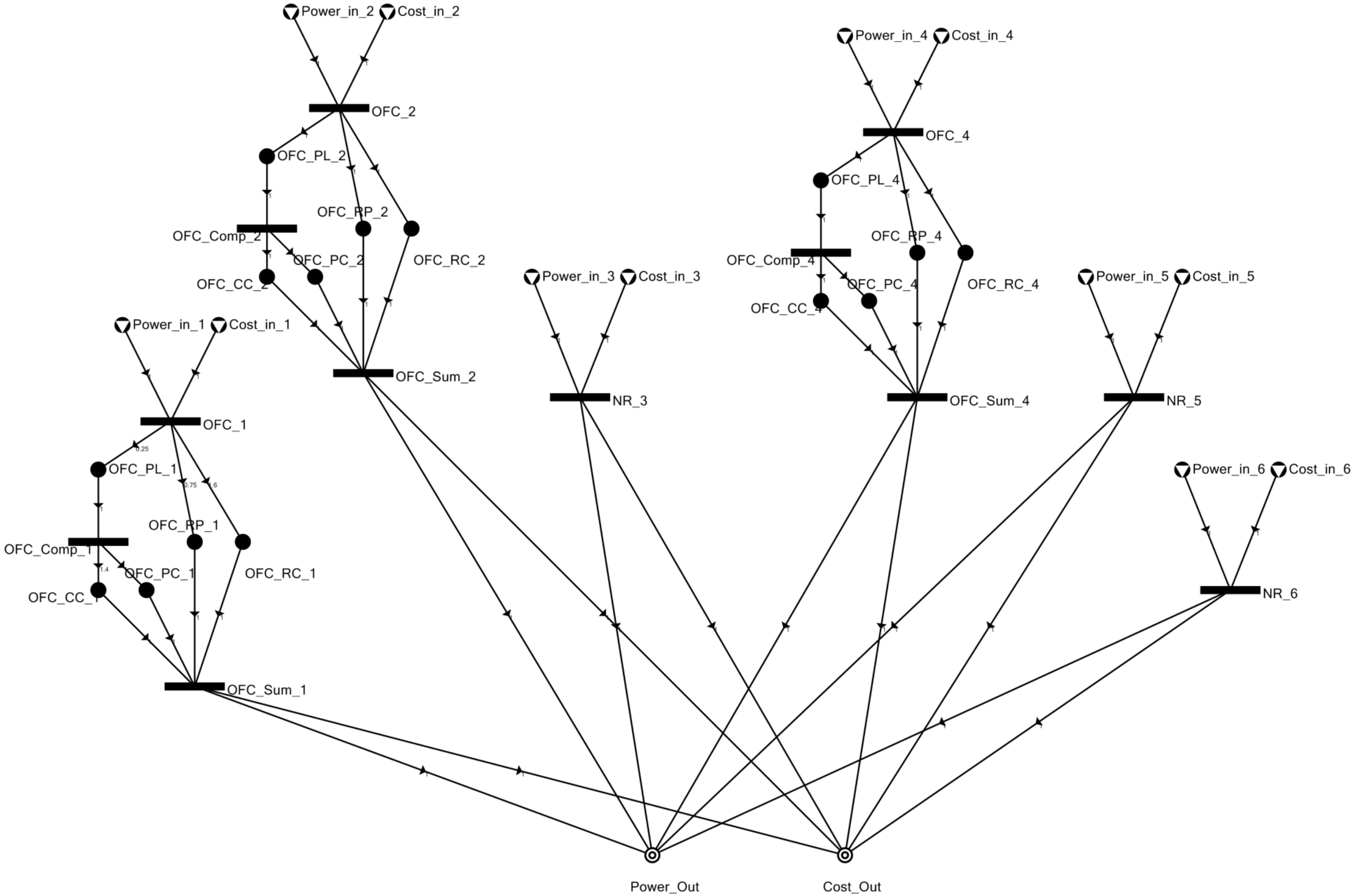

Figure 13: Enlarged view of graphical P-graph solution for retrofitting of power plants in Scenario 1

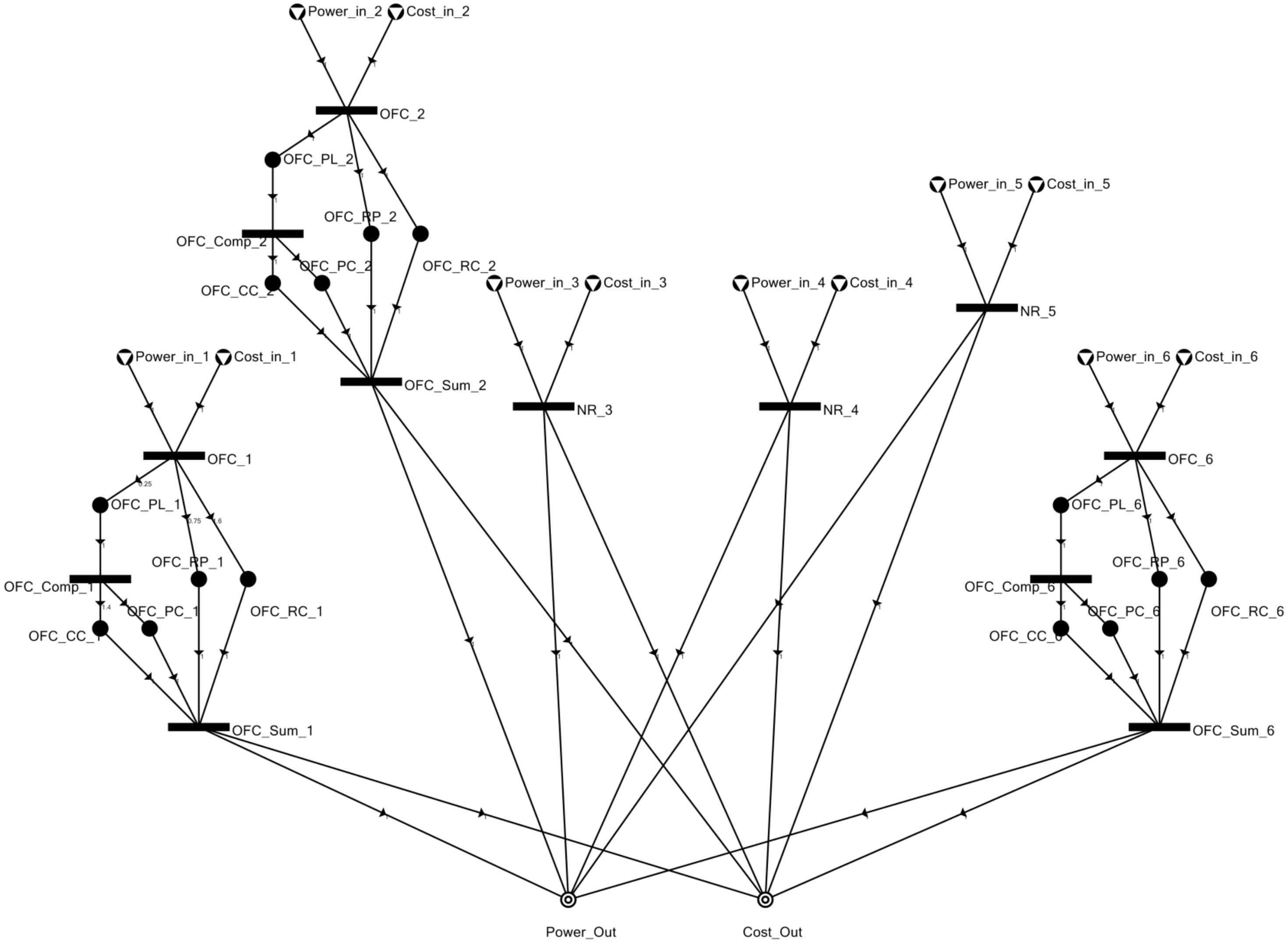

Figure 14: Enlarged view of graphical P-graph solution for retrofitting of power plants in Scenario 2

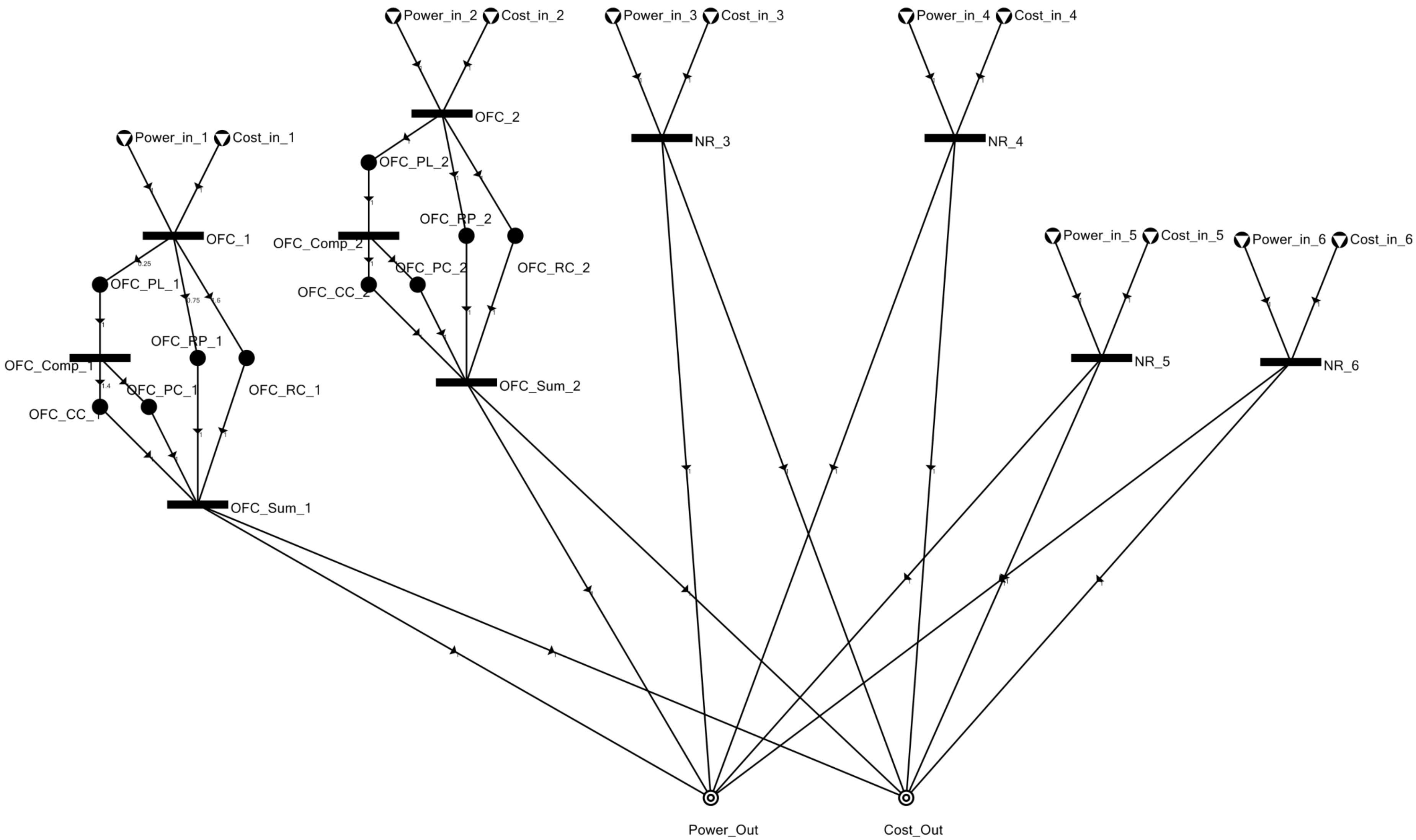

Figure 15: Enlarged view of graphical P-graph solution for retrofitting of power plants in Scenario 3

Consumer Awareness of Carbon Footprint in United Arab Emirates

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A survey of 220 consumers was conducted in the emirate of Abu Dhabi, United Arab Emirates, in spring of 2013. The purpose of this study was to explore the relationship between consumer awareness of carbon footprint and level of education, high school, university and post-university. UAE has one of the highest carbon footprints in the world, as is the trend for major oil-exporting countries. One third of respondents were aware about the term carbon footprint. The findings suggest that an increase in education level and awareness about carbon footprint are not a linear, positive relationship. We find that the relationship is, in fact, slightly negative. We conclude that more specified education is needed to inform the people of UAE about the impact between their consumption decisions and climate change.

Introduction

Carbon dioxide (CO_2) emission resonates as a global problem as consumers, firms, researchers, and policymakers increasingly become more aware of the effects of human activities on greenhouse gas emissions. In the Middle East region per capita carbon emissions are highest in the world, especially within the major oil-exporting countries (World Bank, 2011). United Arab Emirates has been on the fast track of development, coupled with rapid economic growth, which has allowed it people to enjoy a high standard of living.

Carbon footprint (CF) has been popularly coined as a term the public uses to conceptualize the impact of human activities on the global climate and environment for goods and services. The literature shows that the term has no common consensus for defined methods to quantify CF (Wiedmann & J, 2008). Carbon foot has become a way for these negative externalities to be calculated so actors and agencies can compare the impact of their decisions.

The use of non-renewable natural resources; specifically four fossil fuels, carbon dioxide (CO_2), methane, nitrous oxide, and fluorinated gases, are particularly dangerous to the future of humans. When fossil fuels are burned this forces the byproducts into the atmosphere negatively influencing the quality of our air and increasing the greenhouse effect, causing climate change (United States Environmental Protection Agency, 2013).

Greenhouse gases have a direct influence on the environment, causing extreme weather changes, a global temperature increase, the loss of ecosystems and potentially hazardous health effects for people. Out of the four fossil fuels mentioned above, CO_2 emissions are the greatest threat to climate change (see Figure 1).

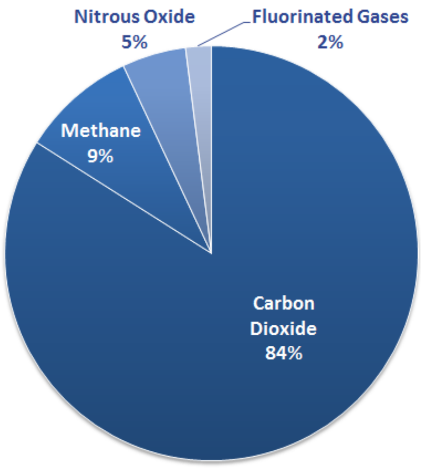


Figure 1: Total emissions in 2011 were 6,702 Million Metric Tons of CO2 equivalent

Objective of this study

The purpose of this study is to explore the relationship between consumer awareness of carbon footprint and level of education. We explore whether the people of United Arab Emirate, one of highest CO2 emitting per capita countries in the world, are familiar with the term CF. Also, if they consider behaviors that are related to household energy consumption, and if there is any relationship between these factors and level of education. A survey of 220 consumers across three levels of education, high school, university and post-university, in the emirate of Abu Dhabi, was conducted. We aimed to understand the following objectives:

1. Explore recognition of the term, carbon footprint, and attempt to link knowledge of the terminology with household consumption behaviors.

2. Determine consumer awareness and attitudes towards human activities and behaviors that cause increased household consumption, across education level.

3. Test our hypothesis that increased carbon foot print awareness has a positive, linear relationship with increased level of education.

The definition of CF varies with the actual measurement technique, as is discussed in the following section. For this study we define carbon footprint generally as the amount of carbon dioxide emitted due to the consumption of fossil fuels by a particular person, good or service.

Problem Statement

Carbon footprint is becoming a global concern because of its link with energy consumption, increasing wealth and economic growth. Higher income countries consume five times the energy of developing economies, on average, but per capita use of energy consumption can be higher or lower based on the efficiency of the countries. For example, China emits more carbon dioxide than any nation in the world but emissions per capita are one quarter of that of UAE (see Figure 2); United States (US) is stated as a reference point for comparison.

Comparing Carbon Emissions for China, United Arab Emirates and United States

	CO_2 emissions	
	(kt)	*(per capita metric tons)*
China	7687114	5.8
UAE	156823	22.6
USA	5299563	17.3

Figure 2: World Bank indicators are used to compare the differences of CO emissions, total and per capita, in select countries **(World Bank, 2013)**.

Country Characteristics

United Arab Emirates has the seventh largest proven reserves of crude oil and natural gas in the world. The country is a net exporter of oil with crude oil exports comprising about 30 percent of Gross Domestic Product (GDP). UAE enjoys a high standard of living since its discovery and independence from the United Kingdom (UK) in 1971. UAE is one of the wealthiest nations in the world with a GDP per capita of $47,890 (purchasing power parity), just behind US (World Bank, 2013).

In the last decades, government investments have been directed at diversifying its economy through tourism, trade and manufacturing. Complimenting these investments is a strong emphasis on education for the local population. Since 1995 the number of national students has increased nearly 70% (United Arab Emirates National Bureau of Statistics, 2012).

In the last decade UAE has experienced a rapid growth in domestic energy demand and is now a net importer of natural gas. One of the reasons for this demand is that domestic energy use has expanded within the residential population. Water is sourced from desalination plants that run on natural gas. Dubai, Abu Dhabi and Sharjah Electricity and Water Authorities, the most populated emirates, have doubled usage from 2005 to 2010 (United Arab Emirates National Bureau of Statistics, 2012). The country has experiences rapid economic and demographic growth in the recent decades (U.S.Energy Information Administration, 2013).

Economic and demographic statistics of the UAE that may be related to the expanded energy consumption; 80% of the population are expatriates, the median income of local population is very high and 40% of the national population is under the age of 28. The confluence of factors in UAE has led to a lifestyle that requires a high use of natural resources. Carbon footprint per capita in UAE is over double that of other high income countries (see figure 3). The significance of carbon footprint awareness in UAE is that if the people have knowledge that their actions can change this pattern, the more likely that UAE can reduce its CF.

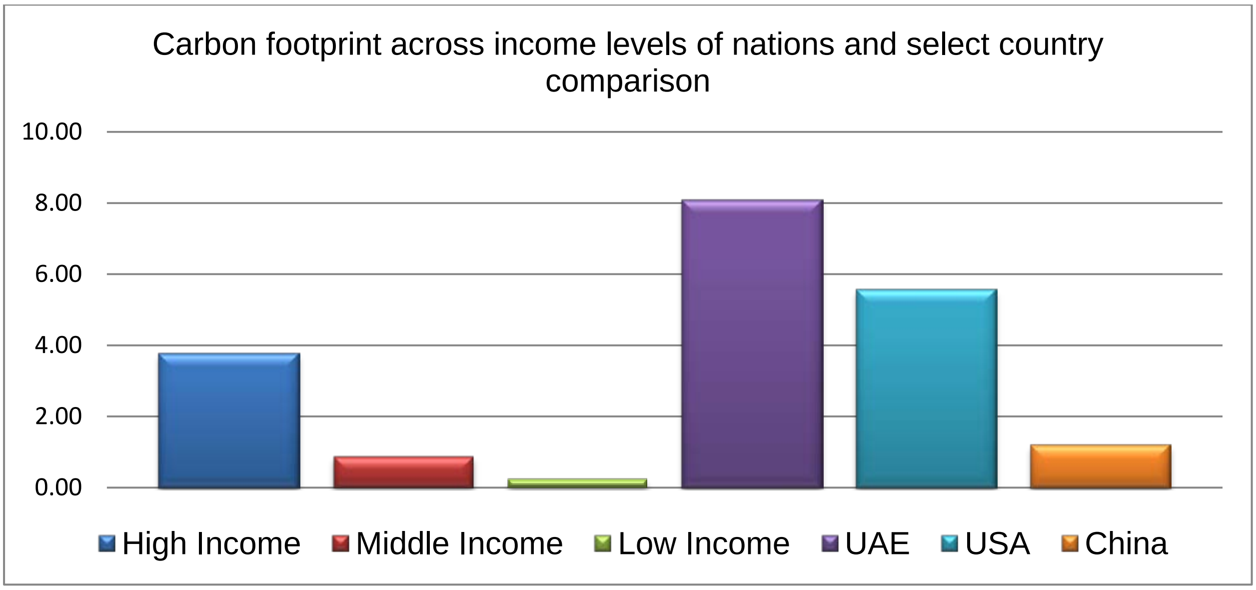


Figure 3: The carbon footprint of UAE is more than double of the average carbon footprint of high income countries and 45% higher than United States of America.

Literature Review

In this section we provide a brief review of key studies that illustrate our motivation for this research. First, the CF definition debate is briefly outlined, and the two most common methodologies used to calculate CF. Then we validate the importance of consumers having some awareness about their activities, especially with respect to household consumption. We present two research studies that have shown carbon emissions is highest due to household activities.

The promulgation of carbon markets, cross national/regional comparisons and CF labeled products give rise to the importance of a clear CF definition and measurement. There is no consensus on how to measure or quantify a carbon footprint, according to the literature. Firms and NGO have taken it upon themselves to define CF for their purposes and this can lead to gross underestimations (Matthews, Hendrickson, & Weber, 2008).

Wiedmann (2008) found eight distinctly different definitions from a literature search ranging from 1960 to 2007. He found that for the most part the term carbon footprint was used as a generic expression for CO2 or GHG emissions as expressed in CO2 equivalents- metric tonnes, or kt. This study proposed a measure of CF based solely on CO2 emissions, directly and indirectly, caused over the life cycle of an activity or product.

The two main methods used to estimate carbon emissions are the end use and sectoral approaches. End use is based on the various end uses, or final consumption, of goods or services such as cars, or air conditioning. Sectoral approach is based on the energy use within a sector of the economy. The approaches most often used in calculating CF are Process Analysis (PA) or Environmental Input-Output (EIO). Process Analysis traces the life cycle of a product from conception to end the products life. The other approach, EIO, uses economic and environmental data to estimate the materials and resources, thus emissions, caused by the activities in the economy (Green Design Institute, 2012).

Household consumption is found to be one of the largest sources of indirect and direct carbon emission (Baiocchi, Minx, Barrett, & Wedmann, 2006; Hertwich & P, 2009). The carbon emission of lifestyle is topic of interest since the Kyoto Protocol has targeted GHG reduction. Sustainable consumption is generally agreed to be required for substantial reduction in the form of more carbon efficient production processes and lifestyle changes (Baiocchi, Minx, Barrett, & Wedmann, 2006).

The environmental significance of lifestyles is investigated by Baiocchi et al (2006) in the United Kingdom (UK). They used the EIO approach with geo-demographic data. Then, they apply a regression to understand the impact of lifestyle on the relationship between emissions and socioeconomic variables. The results found income, large homes and large families as emission determinants.

Providing goods and services in the world's interconnected system of production and consumption has an environmental cost, especially in countries where imports play a large role in the daily consumption of its people. Hertwich (2009) seeks to compare eight consumption activities' CF across 73 nations and 14 regions, using the input-output model approach. The greenhouse gas emissions associated with the final consumption of goods and services for construction, shelter, food, clothing, mobility, manufactured products, services and trade is globally linked between the regions. Household consumption comprised 72% of greenhouse gas emission. Food consumption accounted for 20% of GHG emissions in his study.

Additionally, Hertwich estimated the CF for 87 countries. The footprint varied from 1 ton per person, per year (t/py) in several African countries and Bangladesh, to 28 t/py in US, and the highest in Luxemburg at 33 t/p. The study found the CF of nations is strongly correlated with per capital consumption expenditure; however the Middle East region is not represented in this study.

Methodology and Data

This study uses data collected from 220 surveys, administrated by paper and internet (using Survey Monkey), about half were collected by each method. UAE residents in the town of Al Ain, were surveyed regarding their behavior in the household consumption, as well as the standard demographic questions. Two questions directly asked the respondents about carbon footprint. The survey was composed of 17 questions total. It was piloted with 10 respondents prior to distribution. The survey was distributed among three groups of education level: high school, university, and post-university. The results of the survey were analyzed using SPSS and statistical tests commonly used for nominal and ordinal data.

Sample population characteristics

The majority of the sample were females (82%), not married (72%), and students (80%). Eighty-one percent of the sample respondents were between the ages of 14 and 25. The local ethnicity, Emirati, comprised 76% of the sample population, the remaining were non-local. Household size of over 5 or more people was stated by three-quarters of the sample. Nearly 60% of the respondents claimed a monthly income greater than $8,100 (US).

Results

The survey results follow according the stated objectives.

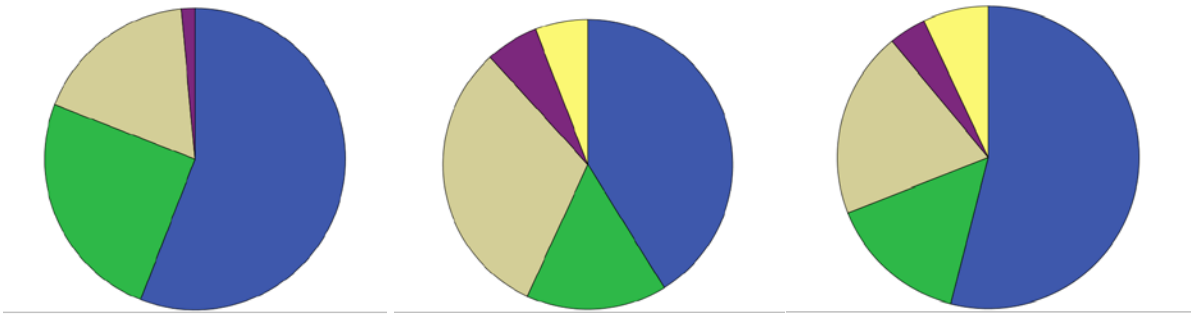
1. Explore recognition of the term, carbon footprint, and attempt to link knowledge of the terminology with household consumption behaviors.

We found that 69% of respondents did not recognize the term carbon footprint by checking, “no” or “not sure”. The overall results were random when we explored the relationship between recognition of the term and questions about household consumption behaviors.

- Males were more likely to recognize the term than females. Higher income brackets were less likely to identify the term than those with lower household income.
- An Emirati respondent was equally as likely to recognize, not recognize, or be not sure about the term carbon footprint, no locals.
- The respondents who recognized the term CF were not more likely to practice behaviors that reduced energy consumption (see figure 4). The behavior was nearly the same action across the three groups of awareness.

Do you consider switching off the lights when you leave the room?[1]

[1] Blue- always, green- almost always, tan- sometimes, purple- almost never, yellow- never



CF Awareness:

Yes Not sure No

Figure 4: Comparing CF awareness with respondents' household energy consumption behavior

Based on the data analysis of cross tabulations between the variables of CF awareness (Yes, Not sure, No) and the questions regarding household consumption activates, the respondents do not, on average, have a high level of consumer awareness about their activities on increased household consumption.

2. Determine consumer awareness and attitudes towards human activities and behaviors that cause increased household consumption, across education level.

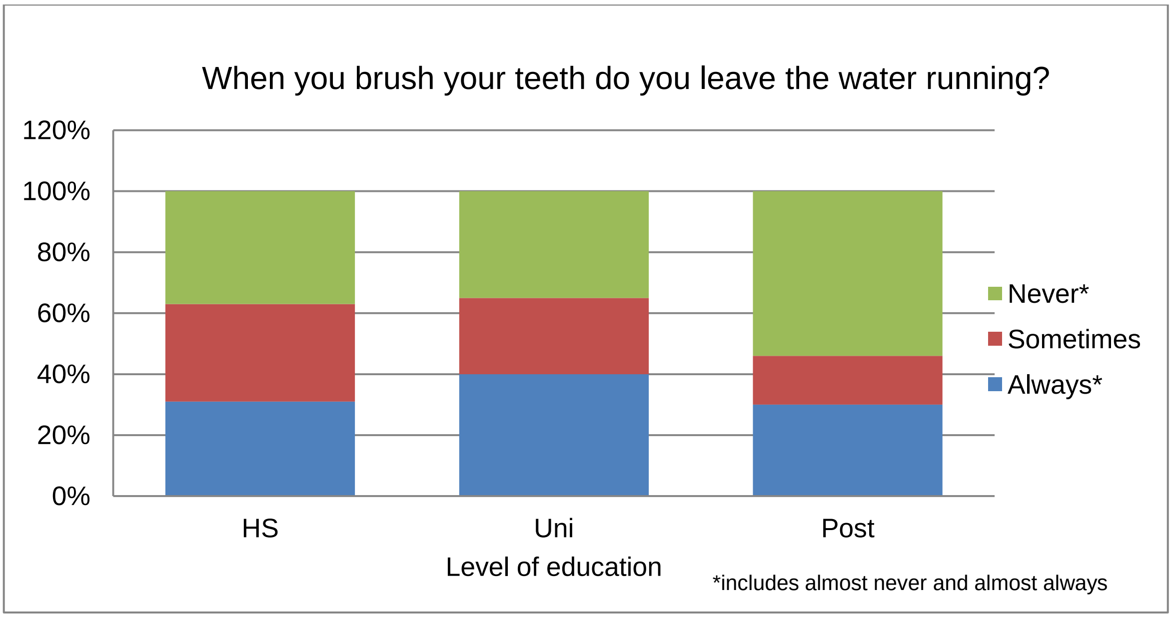


Figure 5. Example of respondents' household behavior across education level

As shown in Figure 5, the respondents did not display any type of pattern across the nine questions in the survey that asked about behaviors in the household that can reduce household energy consumption. The pattern identify was random across education levels.

Correlations

		Your education?	Have you ever heard about Carbon foot print?	Marital Status?	Age?	Employment Status?
Your education?	Pearson Correlation	1	-.164*	.250**	.610**	.380**
	Sig. (2-tailed)		.015	.000	.000	.000
Have you ever heard about Carbon foot print?	Pearson Correlation	-.164*	1	-.141*	-.208**	-.066
	Sig. (2-tailed)	.015		.037	.002	.328
Marital Status?	Pearson Correlation	.250**	-.141*	1	.491**	.367**
	Sig. (2-tailed)	.000	.037		.000	.000
Age?	Pearson Correlation	.610**	-.208**	.491**	1	.638**
	Sig. (2-tailed)	.000	.002	.000		.000
Employment Status?	Pearson Correlation	.380**	-.066	.367**	.638**	1
	Sig. (2-tailed)	.000	.328	.000	.000	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

3. Test our hypothesis that increased carbon foot print awareness has a positive, linear relationship with increased level of education.

Figure 6. Correlation table for demographic variables and CF awareness

We tested our hypothesis using a standard Pearson Correlation and linear regression model. The variables for education and carbon footprint awareness were found to have a statistically significant negative relationship, according to the statistics Pearson Correlational, at the level -.164. The level of significance between these two variables is equal to 0.015) which is according to our alpha 0.05 is significant. In order to test our data we ran a Pearson Correlational between the variables of education and age and found a statistically significant positive linear relationship with a value of 0.610.

Conclusion

The objective of this study was to explore carbon footprint awareness in the United Arab Emirates, one of the highest per capita CF nations in the world. The survey results show carbon footprint awareness does not increase with education levels. Additionally, we did not find statistically significant differences across educational levels, incomes or local and non-local respondents, and household consumption decisions that may reduce energy consumption.

The people of UAE need to be better informed of their consumption decisions in order to reduce carbon emissions. We suggest that the government of UAE approach this matter with promotional programs to increase awareness. Promotional programs have worked in other nations to reduce litter, increase awareness about health and safety issues. The people of UAE should act before the matter of climate change worsens, or the natural resources of the nation cease.

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Cr(III) ADSORPTION POTENTIAL OF FUNGI

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ABSTRACT

Biosorption by macromycetes (fungi) has been projected as an alternative to expensive and cautionary chemical based procedures opted for purification of metal-bearing effluents. In the present study, the biosorption potential of three species of Basidiomycetous fungi namely *Schizophyllum commune* Fries, *Ganoderma lucidum* (Curt. Fr.) P. Karst and *Pleurotus ostreatus* (Jacq.) Quélet was evaluated for removing Cr(III) ions from wastewater of tannery treatment plant (TTP). Experiments were performed as a function of pH, biomass dose, equilibrium time and initial metal ion concentrations. Results showed, *S. commune* exhibited the highest removal of Cr(III) followed by *P. ostreatus* and *G. lucidum*. Solution pH evaluated between a range of 2.0-6.0, revealed negligible uptake of metal at pH < 3.5 and adsorption efficiency reached plateau at around pH 4.5-5.0. On increasing adsorbent doses within range of 0.03-0.8 g, a considerable improvement in adsorption efficiency was noticed. Equilibrium was obtained in contact time of 1 hour for both *S. commune* and *P. ostreatus* and in 3 hours by *G. lucidum*. The regenerated fungal biomass, reemployed in at least four cycles of biosorption, showed no significant loss in heavy metal removing capacity with high desorption capacity of *P. ostreatus* (> 89%) in comparison to rest of two fungi (> 87%). The distribution of metallic ions between liquid and solid phase was adequately described by Langmuir and Freundlich isotherms model. With actual water of tannery treatment plant, *P. ostreatus* exhibited 55% sorption efficiency followed by 43% efficiency by both *S. commune* and *G. lucidum* for Cr(III) ions. To make this technique economically feasible, the study was further extended by mass cultivated this fungus on wheat straw and assessment of biosorption potency of colonized wheat straw for Cr(III) ions. Wheat straw colonized with either of three fungi mycelia possessed tremendous ability to remove Cr(III) (removal efficiency: 70-90%) from aqueous solution thus could be utilized as an excellent biosorbent for Cr(III) adsorption at low concentration of the metal ions(4-20 mg L^{-1}).
Keywords: Biosorption, Basidiomycetes, heavy metals, fungi

INTRODUCTION

Chromium is categorized amongst the 17th leading element on lithosphere, top 16th noxious contaminant owing to its carcinogenic and teratogenic effects on the individuals (Rehman *et al*., 2011). Generally, chromium exists in nine valence states ranging from 2 to 6 but Cr(III) and Cr(VI) are most dominant because of their immovability in natural environment (Poornima *et al*., 2010). Many countries including Pakistan are facing problems of contamination of soil and water with Cr from different sources including electroplating, tanning industries and textiles and its concentration above 0.05 mg/L considered to be toxic (Suwalsky *et al*., 2008). Utilization of Cr(III) primarily as a tanning agent seriously deteriorating groundwater qualities around tanneries (Sameera *et al*., 2011) and many cases have been reported in Pakistan (Nasreen, 2006; Rizwan Ullah *et al*., 2009; Mushtaq and Khan, 2010). Although Cr(III) is less mobile and less noxious than Cr(VI) but former species could be toxic to plants through persistence bonding to organic matter in soil and aquatic environment (Becquer *et al*., 2003). Yet, major drawbacks for utilization usual methods for chromium removal (Vinodhini and Das, 2009) reverts attentions towards biological methods. Biosorption based on binding capability of various biological materials is a preferred prospective option because of its high efficiency, easy handling and simple accessibility to the biosorbent materials (Akhtar and Shoaib, 2012). Of recent, the use of fungi for depollution of heavy metal ions has been gaining advantage due to their filamentous morphology, robust nature, high percentage of cell wall material, required in small amount and efficiently adsorbs metal along with reutilization and desorption capabilities. Current investigation was conducted to explore Cr(III) removal potential of three members of basidiomycees from aqueous solution. In this regard, preliminary batch biosorption trials were performed with synthetic solution of Cr(III) ions under varying pH values, biomass doses, time duration and initial metal ion concentrations followed by trials with real metal bearing water. For large scale industrial application, fungal biosorbent/s was mass cultivated on agro-waste and was evaluated for its metal sequestering ability.

EXPERIMENTAL PROCEDURE

The stock solutions of Cr(III) were prepared by dissolving 7.70 g $Cr(NO_3)_{2}.9H_2O$ (Merck Germany) in one liter of distilled water. Further dilutions were made from the stock solution with double distilled water. Test fungi were procured from First Fungal Culture Bank of Pakistan (FCBP), Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan. Adsorption trials were conducted by contacting measured amount of dried fungal biomass with 100 mL of 15 mg/L of metal solution in 250 mL flask kept at 150 rpm for 12 hours. Samples were also analyzed from experimental control, which contained no biomass. pH assessment trials were performed at values of 1, 2, 3, 4 and 6 at the similar parameters as mentioned in above section. Influence of initial concentration of metal ions was investigated over the range of 4-20 mg/L at constant adsorbent dose, pH and temperature. Time profile was investigated over period of 15min to 360 min. The rate of stirring intensity was checked over the range of 0 to 200 rpm. After adsorption, the fungal biomass was checked for its metal desorption capability according to method of Arica *et al*. (2004). Remaining Cr concentration of the triplicate samples was analyzed through Atomic absorption spectrophotometer (AAS). The amount of Ni(II) accumulated by biomass (q in mg g^{-1}) and efficiency (%) of biosorbents were calculated by following formulas.

$$q = \left(\frac{C_i - C_f}{m}\right)V \qquad E = \left(\frac{C_i - C_f}{C_i}\right)*100$$

C_i is the initial concentration of the metallic ion (mg L^{-1}); **C_f** is the final concentration of metallic ion (mg L^{-1}); m = dried mass of the biosorbent in the reaction mixture (g); **V** = volume of reaction mixture (mL).
Langmuir (1916) and Freundlich (1906), adsorption isotherm models were applied on experimental data acquired through biosorption experiments at different initial concentration of Cr(III) in aqueous solution.

After optimizing important parameters, batch experiments were conducted with real wastewater of tannery treatment plant (TTP). After that each of the fungal species was cultivated on wheat straw by inoculating 0.5–1 mm disc on pre-autoclaved straw filled in plastic bags. Bags were kept in incubator at 25 ± 1 °C until the mycelium of each fungus had fully penetrated to the bottom of the substrate and ramified the whole substrate. Colonized straw was dried in oven at 60 °C and homogenised to obtain particle size of 150 µm mesh and utilized to perform biosorption experiments with real wastewater of TTP. Results were calculated in term of adorption capacity and efficiency for the fungal biomass.

RESULTS AND DISCUSSION

Effect of pH

The maximum adsorption efficiency (31.01%) for uptake of Cr(III) ions was recorded for the biomass of *S. commune* at pH 5.0 and optimum range observed was between pH 4.5-5.5 (29.5%). Both, *G. lucidum* and *P. ostreatus* demonstrated optimum pH range of 4.5-5.0, the 4.5 being optimum pH for efficient metal ion removal efficiency (30%). When pH is low (2-3) then more protonation of metal binding sites is possible which usually not prefer positive charge ions. However, on increasing pH (4-5), reduction in electrostatic repulsion is directly proportional to drop in positive charge density on the metal capturing groups thus an increase metal biosorption (Sari *et al*., 2007) (Fig. 3.1).

--------- Biosorption capacity, — Biosorption efficiency
◆*S. commune*, + *G. lucidum*, ● *P. ostreatus*

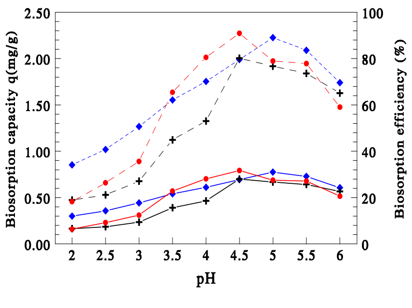


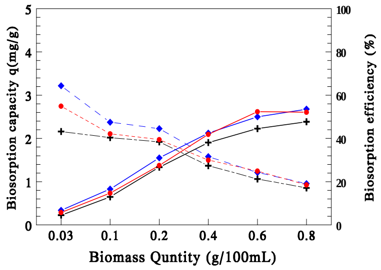
Fig. 3.1: Effect of pH on biosorption potential of the test fungal species for Cr(III)

Influence of biomass quantity

When fungal biomass dose was increased from 0.03-0.08 g in the reaction mixture, the adsorption efficiency was reduced by 70% and adsorption capacity was increased about 10-times (Fig. 3.2). Previous studied also supported this factor of increased metal ion removal with an increase in biomass on the basis of intensification in available active sites for adsorption (Park *et al*., 2005).

--------- **Biosorption capacity,** — **Biosorption efficiency**
◆ ***S. commune.*** + ***G. lucidum.*** ● ***P. ostreatus***

Fig. 3.2: Effect of biomass quantity on biosorption potential of the test fungal species for Cr(III) ions

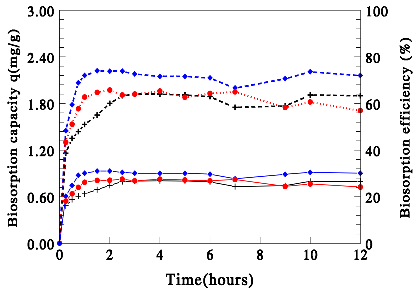


Biosorption rate

The detention time (biosorption equilibrium) was achieved in 1 hour by *S. commune* and *P. ostreatus* and 3 hours by *G. lucidum* (Fig. 3.3). The fast Cr(III) ion uptake by *S. commune* and *P. ostreatus* suggests a practical use guaranteeing high efficacy and economy.

--------- **Biosorption capacity,** — **Biosorption efficiency**
◆***S. commune,*** + ***G. lucidum,*** ●***P. ostreatus***

Fig. 3.3: Kinetic profiles of Cr(III) ions sorption.

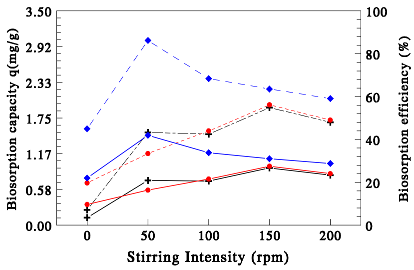


Effect of stirring intensity

There was considerable increase in the metal removal ability of the each fungus with increasing rotation speed. Biomass of *S. commune* exhibited a maximum adsorption at 50 rpm, and for *G. lucidum* and *P. ostreatus* maximum was evidenced at 150 rpm. This is expected because rotations provide suitable time to biomass to contact with heavy and promotes effective transfer of sorbate ion to the sorbent sites (Fig. 3.4).

--------- **Biosorption capacity,** — **Biosorption efficiency**
◆***S. commune,*** + ***G. lucidum,*** ●***P. ostreatus***

Fig. 3.4: Effect of stirring intensity on sorption potential of the test fungal species for Cr(III) ions



Batch isotherm experiments

When biomass of each of three fungal species was brought in contact with different 5 concentrations of Cr viz. 4-20 mg L^{-1}, the adsorption capacity increased with growing metal ion concentration. The decrease in removal efficiency could probably be linked with inadequate metal binding sites on biomass cell wall, due to saturation factor over a certain concentration. Whereas, upturn in biosorption capacity due to increasing metal concentration could be correlated with capturing of every biding group on biomass surface at higher concentration (Yousefi *et al*., 2011) (Table 1).

Table 1: Isotherm model parameters for the biosorption of Cr(III)

Desorption/reusability test

Test fungi	q_{exp} (mg g^{-1})	Langmuir			Freundlich		
		q_m (mg g^{-1})	b (mg L^{-1})	R^2	K_F	n	R^2
S. commune	2.23	3.64	0.20	0.99	1.44	1.84	0.99
G. lucidum	1.92	2.16	0.42	0.91	1.37	2.59	0.96
P. ostreatus	1.97	2.36	0.36	0.92	1.41	2.30	0.94

Amongst three fungi the highest desorption efficiency was exhibited by *P. ostreatus* (95%) followed by *G. lucidum* (93%) and *S. commune* (92%). Diniz and Volesky (2006) confirmed in their studies that mineral acids like hydrochloric acid and nitric acid seem to be the most practicably applicable eluting agents. They also revealed that a new low-pH equilibrium attained in the desorption system during weak acidity, that prevent the arrant elution and discharge of the adsorbate metal ion into the solution.

Biosorptin assays with wastewater of tannery

The physic-chemical characters of the wastewater of TTP are presented in Table 2. The optimized conditions selected for the candidate fungi from biosorption assays were applied to conduct experiment for removal of Cr(III) ion present with wastewater of tannery treatment plant. Results obtained revealed no indication of any reduction in biosorption efficacy of the test fungal species for Cr(III) ions despite the fact that the tannery wastewater carried differential impurities in the form of nutrients, anions and cations Na^+, Mg, Ca^{2+}, K^+, Cl^-, SO_4^-, CO_3^-, HCO_3^- and TDS along with high pertaining values of BOD and COD.

Table 2: Physico-Chemical Characterization of waste water of Tannery Treatment Plant. Pakistan

Sr.#	Parameters	Wastewater of tannery treatment plant	*NEQS Acceptable limits	**WHO Acceptable limits
1.	Copper (II), mg L^{-1}	1.21	1.00	0.20
2.	Chromium (III), mg L^{-1}	14.35	1.00	0.10
3.	Nickel (II), mg L^{-1}	0.05	1.00	0.20
4.	Zinc (II), mg L^{-1}	0.54	5.00	2.00
5.	pH Value (acidicity/basicity)	8.5-9.5	6.0-10	No guideline
7.	Biochemical Oxygen Demand (BOD) at 20°C, mg L^{-1}	500	80	No guideline
8.	Chemical Oxygen Demand (COD), mg L^{-1}	4000	150	No guideline
9.	Total Dissolved Solids (TDS), mg L^{-1}	1510	3500	No guideline

*****National Environmental Quality Standards (NEQS) for liquid Industrial Effluents
******World Health organization Standards (WHO) for drinking water

Adsorption trials with colonized wheat straw

Generally, wheat straw either colonized or uncolonized found to be good adsorbent of Cr(III) ions (Table 3). In a number of previous findings, agro waste was regarded as good biosorbents for removal of different metal ions (El-Sayed *et al*., 2010; Dhir and Kumar, 2010; Singha and Das, 2013). Probably, active binding site on cell wall of straw contains configuration of cellulose molecules surrounded by hemicellulosic, lignin and pectin along with small amounts of protein (Mtui, 2009).

Table 3. Comparison of adsorption efficiency of test fungal species for uptake of Cr(III) from wastewater of tannery treatment plant.

fungi	**Adsorption efficiency of biomass cultivated on wheat straw**	
	Oven dried	**Sun dried**
S. commune	83.40±0.13	86.00±0.20
G. lucidum	82.44±0.10	84.12±0.22
P. ostreatus	86.00±0.12	91.33±0.24

± indicates standard error of means of three replicates

Conclusion

The present study concludes that all the three fungal species have potential to remove heavy metals from the tannery industrial effluents under specific condition of pH, biomasss dose, equilibrium time, rotation speed and initial metal ion concentration. The performance of these macromycetous fungi can be further enhanced by culturing them on agro-waste such as wheat straw. The present study will open new vistas for management of heavy metal contaminated industrial effluent using low cost and environmental friendly biological methods.

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DETERMINATION OF SEDIMENT CHARACTHERISTICS BASED ON GRAIN SIZE OF SEDIMENTS OF PERLIS RIVER

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ABSTRACT

The grain sizes analysis were investigated in the surficial sediments of Perlis River that involved 10 stations along the river based on four different seasons, Southwest Monsoon, Pre-monsoon, Northeast monsoon and Post-monsoon. For Southwest monsoon, the average of sediment mean size ranged 7.00 to 8.01 phi which dominated by medium silt to very fine silt (7.28±0.31phi).The sediment sorting value ranged from 1.39 to 1.69 phi whereas the skewness ranged from -0.24 to 0.04 phi. Average of these two factors indicates the sediment were poorly sorted (1.51±0.09) and were symmetrical (-0.08±0.09).For Pre-monsoon, the average of sediment mean size ranged from 6.94 to 7.60 phi, indicated that the river were predominated by coarse silt to fine silt (7.23±0.19 phi). The sediment sorting value ranged from 1.35 to 1.57 phi whereas the skewness ranged from -0.12 to 0.12 phi. The average of these two factors showed that sediments were poorly sorted (1.44±0.07 phi) and were symmetrical (0.01±0.09 phi). Meanwhile, for Northeast monsoon, the sediment mean size ranged from 6.58 to 7.62 phi which shows that the river were predominated by medium silt to fine silt (7.17±0.33 phi). The sediment sorting value ranged from 1.33 to 1.78 phi while the skewness ranged from -0.54 to 0.13 phi. Hence, these two factors showed that the sediment were poorly sorted (1.58±0.13 phi) and were symmetrical (-0.11 ±0.20 phi). For Post-Monsoon, the sediment mean size ranged 6.53 to 8.42 phi which in average, indicated that the river were predominated by medium silt to very fine silt (7.18 ±0.50 phi) also. The sediment sorting for this season show the value ranged from 1.43 to 1.78 phi while the skewness ranged from -1.15 to 0.13phi. The average of these two factors indicated that the sediment were poorly sorted (1.54±0.11 phi) and were symmetrical (-0.15±0.36). Overall, based on the data obtained, the determination of sediments characteristics based on the grain size fractions indicated that most of the river area was predominated by fine silt sediments (<63µm). Statistical analyses revealed that the patterns of sediments in Perlis River were more influenced by anthropogenic factor and result infdicate that that seasonal variation not much influences the distribution of river sediments.

Keywords: Grain size;Mean;Sorting;Skewness;Seasonal variations;Sediments

INTRODUCTION

The sediment of the river can be used to indicate the level of pollution because it contains various types of hazardous and toxic substances (Zabetoglou *et al.*, 2002). Sediment consists of mineral or organic solid matter that is washed or blown from land into water sources. Most of sediments capable to serve a high storage capacity of contaminants such as metals which consists around 99.9% in sediments and soils (Pradit *et al.,* 2009). The contaminated sediments are mostly responsible for degradation of water quality in the natural waters especially in the shallow and enclosed water systems (Toluna *et al.,* 2001). Thus, sediment analysis is particularly useful in detecting pollution levels at certain critical sites of the marine environment. The characteristic of sediment such as mean size, skewness and sorting can be measure using its grain sizes and widely used to reconstruct the depositional environments of sediments and sedimentary rocks (Amaral, *et al.* 1977). Grain size therefore plays an important role in determining metal concentrations in fluvial sediments. In this research, sediment characteristic were studied based on the grain size of sediment of selected sampling location in Perlis River.

MATERIALS AND METHODS

10 stations were located throughout Perlis River (Figure 1) and the sampling location were determines based on the GPS (Global Positioning System). A total of 120 surface sediments from 10 stations along the river were collected using Van Veen Grab during four different seasons: Southwest monsoon (5-7), Pre-monsoon(8-10), Northeast monsoon(11-12) and Post-monsoon(1-4).

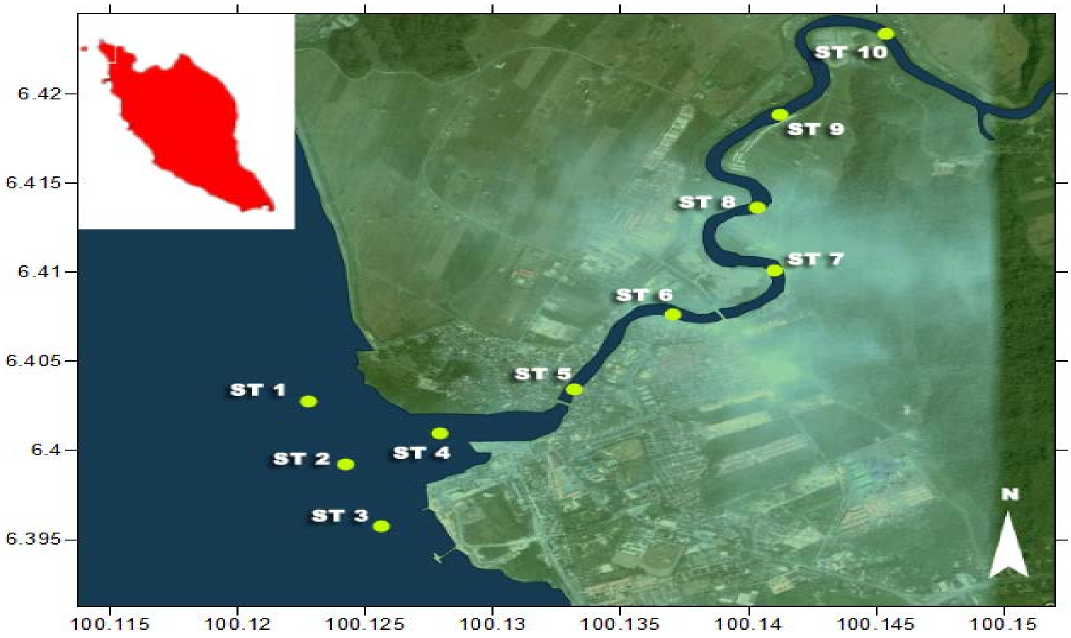

FIGURE 1 Sampling stations along Perlis River

Grain size analyses of sediments were carried out based on the diameter size of the particles. For coarse fraction, sediment particles with diameter greater than 63µm were analysed using dry sieving method but for silt and clay (particles with diameter less than 63µm), laser diffraction method was employed to obtain the statistical value. In this study, the sediments were dried at 60-70^{0}C for 48 hours before grinded and sieved through 63 µm mesh size and were subjected to laser diffraction method performed with Malvern Mastersiver 2000 which measures particles in a wide range from 0.02 µm to 2.0 mm.

Samples with > 10 % fine sediments were analysed using a laser diffraction method to determine the statistical values of sediments by using MALVERN MasterSizer2000 a programmed. The laser detection method is based on the principle of laser ensemble light scattering. This equipment uses Helium-Neon (He-Ne) laser transmission focused on the samples through a focus lens depending on the size of the particles. Focus lens of 45 mm, 100 mm or 300 mm are available to detect different size range of particles.The 45mm focus lens is used to detect the fine particles with sizes ranging between 0.1µm to 80µm. The 100mm focus lens is used to detect medium fine particles with sizes ranging be-tween 0.5µm to 180µm while the 300mm focus lens is used to determine coarse particles with sizes ranging between 1.2µm to 600µm.

For analysis using laser diffraction technique, initially 10 g of sieved samples is prepared by removing the carbonate and organic matters by treating with 10% dilute hydrochloric acid and 20% hydrogen peroxide (H_2O_2) respectively. The reaction is considered complete when no more bubbles formed after addition of hydrogen peroxide. After this, cool the samples and left to precipitate. The next day, clean the samples by removing the supernatant. Subsequently, the flocs of finer particles were broken up by adding a dispersing agent (5% calgon solution) into the samples. The solution is then stirred, and subject to ultrasonic burst of 10 to 15 seconds duration, before pouring in to the Malvern MasterSizer2000. Then, the result from this system was used to calculate the sediment parameters of mean, skewness, sorting and kurtosis (McBride, 1971). Additionally percent-age of clay, silt and sand are also calculated to determine the texture of sediment using classification standard proposed by Nichols and Biggs (1985). Data was analysed using Multivariate analysis methods such as T-Test (paired sample) analysis, to get the information from this data analysis and a value of $p < 0.05$ was considered to indicate a significant difference in all statistical analysis and $p > 0.05$ is vice-versa The statistical analyses were performed with SPSS version 20.0 and Microsoft Office Excel 2010 Data Analysis

RESULT AND DISCUSSION

The distributions of sediment characteristic in Perlis River may influence from various sources such as tidal current, seasonal changes and river flow and boating activities. This causes the fluctuation in sediment composition and grain size of the surface sediment. The grain size parameters such mean size, sorting and skewness which are fundamental in studies the features of sediments of Perlis River were also identified in this study. The distributions of grain size analysis along Perlis River in four different seasons were showed in table 1 below.

Stations	Mean Size				Sorting				Skewness			
	SW	PreM	NE	PostM	SW	PreM	NE	PostM	SW	PreM	NE	PostM
1	7.04	7.20	6.58	6.75	1.69	1.57	1.78	1.78	0.04	-0.12	0.04	-0.04
2	7.19	6.94	6.86	6.89	1.56	1.51	1.66	1.64	-0.05	0.03	-0.15	-0.15
3	8.01	7.60	6.89	8.42	1.41	1.35	1.54	1.64	-0.24	0.07	0.13	-1.15
4	7.01	7.04	7.02	7.08	1.55	1.47	1.54	1.51	-0.13	0.05	-0.05	-0.23
5	7.17	7.14	7.34	7.25	1.50	1.47	1.53	1.44	-0.18	0.04	-0.07	0.00
6	7.21	7.27	7.48	7.28	1.51	1.38	1.33	1.43	-0.08	0.09	0.06	0.00
7	7.20	7.23	7.23	7.21	1.45	1.45	1.68	1.48	0.04	-0.10	-0.54	-0.02
8	7.54	7.40	7.16	7.19	1.39	1.42	1.68	1.48	-0.08	-0.10	-0.35	-0.06
9	7.45	7.35	7.48	7.19	1.57	1.36	1.48	1.55	-0.08	0.05	-0.04	-0.02
10	7.00	7.15	7.62	6.53	1.49	1.46	1.57	1.44	-0.04	0.12	-0.08	0.13
AVERAGE	7.28	7.23	7.17	7.18	1.51	1.44	1.58	1.54	-0.08	0.01	-0.11	-0.15
STD DEV	0.31	0.19	0.33	0.50	0.09	0.07	0.13	0.11	0.09	0.09	0.20	0.36

Table 1: Grains sizes analysis alonf Perlis River in Southwest Moonson (SW), Pre-Moonson (PreM), Northeast Moonson (NE) and Post Moonson(PostM)

The value from mean size acts as indicator of the magnitude of the force, applied by water that transports the grains. The mean size (Figure 2) was measured primarily to recognize the size of sediment that constituted the Perlis River.

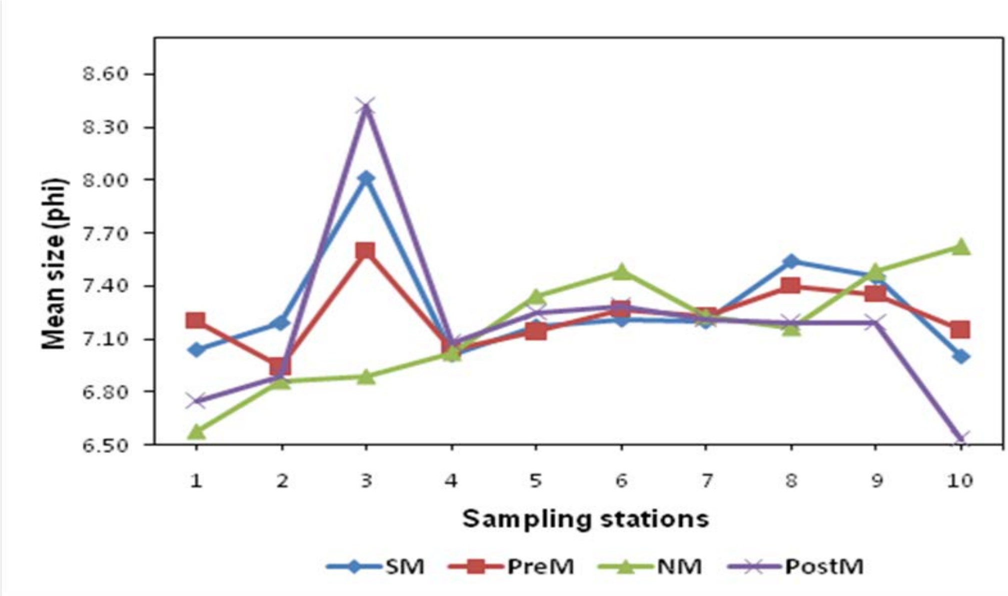

FIGURE 2 The distribution of mean size at each station along Perlis River during various seasons

The mean value along Perlis River ranged from 6.53 to 8.42 phi dominated by medium silt to very fine silt. During Southwest Monsoon, an average mean size was highest (7.28 ± 0.31phi) while lowest during Northeast Monsoon (7.17 ± 0.33 phi). It showed that the sediments in Perlis River were made up of silt as all stations recorded a mean size higher than 4.00 (phi). Post monsoon showed the highest and lowest mean size value at S.t 3 (8.42 phi) and S.t 10 (6.53 phi) respectively rather than other seasons.

The sediments tend to be coarser towards the upstream for all seasons which might influence by the abrasion processes as proposed by Singh et al. (2007) which can be consider causing the downstream area decrease in grain size rather than upstream area. The results might also influenced by the high current velocity due to land runoff (Jamil, 2006) during monsoon season and high hydrodynamic energy (Friedman, 1961) along the river due to active boating activities. Monsoon season which commonly associated with heavy rainfall and high current velocity could cause coarser sediment to be brought to the downstream area and flushed out to the sea (Jamil et. al. 2004). However, according to statistical analysis shown no significant difference ($p>0.05$) for both between mean size and stations and also mean size and seasons. Sorting was applied to estimates the degree of variability of the sediments sizes distributions. Good sorting (well sorted) value indicated by small sorting value means that large selection of grain had taken place during the transport and deposition of sediment. The distribution of sorting of Sungai Perlis is illustrated in Figure 3.

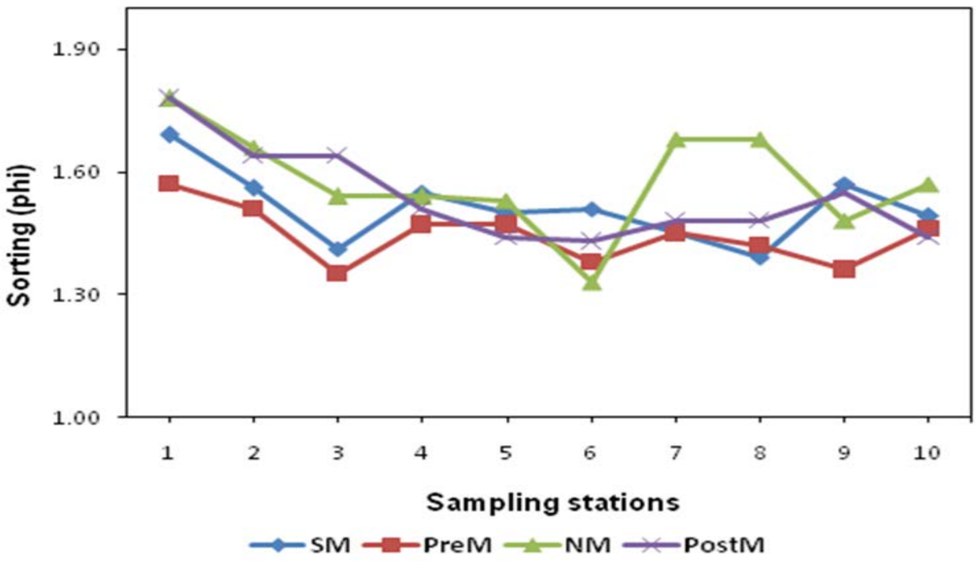

FIGURE 3 The distribution of sorting at each station along Perlis river during various seasons

On average, the sediments sorting in Perlis River were in range of 1.33 to 1.78 phi indicates sediments were dominated by poorly sorted towards the upstream. The highest sorting value of 1.78 phi were recorded during Northeast monsoon and Post monsoon both at S.t 1 while the S.t 6 during Northeast monsoon showed the lowest with the value of 1.33 phi.

The result at S.t 1 might due to the influenced by water flow characteristics during the seasons. This was approved based on the statement by Singh *et al.* (2007) who confirmed that sorting of river sediments mainly controlled by water flow properties. This means that during monsoon season, the channels flows was mostly very sluggish and little sediment was transported, leads to large-scale water and sediment movements on the land surface. According to Krumbein and Graybill (1965), the poorly sorted sediment may also result from poor percolation which may cause sediment to spread unevenly and finally cause sediment to be distributed in various sizes. Apparently, statistical T-test analysis showed the significantly different ($p<0.05$) between the sorting with stations and seasons might influenced by the impact of hydrodynamic energy of the current velocity.

Skewness is the measures of the degree of symmetry showing the distribution of data to spread preferentially to one side of the average value and indicates either the sediment consist of an excess of fine or coarse fractions. The distribution of skewness of Perlis River is illustrated in Figure 4.

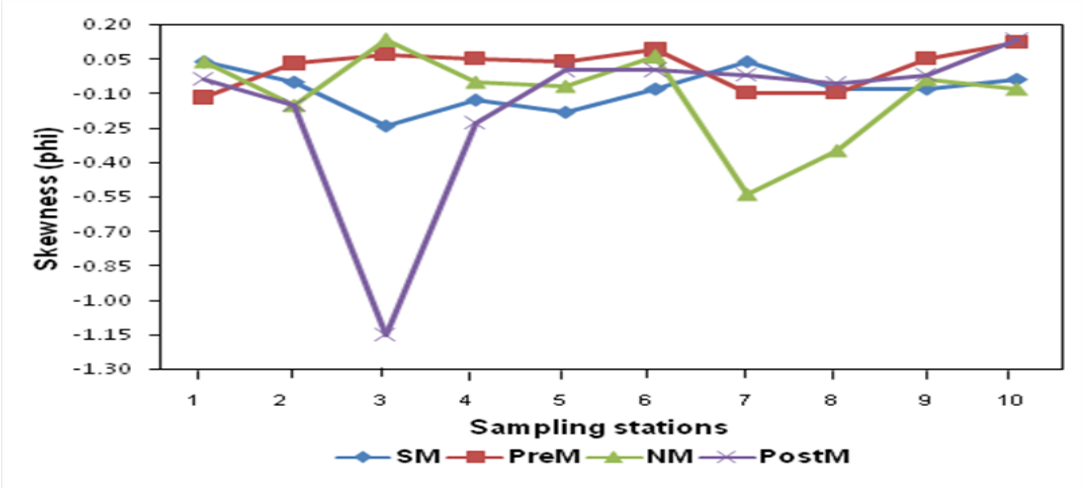

FIGURE 4 The distribution of skewness at each station along Perlis river during various seasons

In this study, skewness in Perlis River sediments showed a wide ranged from -1.15 to 0.13 phi. The values of each season were fluctuate as Northeast monsoon showed the highest value (0.13 phi) and Post monsoon showed the lowest value (-1.15 phi), both at S.t 3 which falls in range of very coarse skewed to symmetrical skewed. The highest average skewness was during Pre monsoon season (0.01±0.09 phi) while the lowest average skewness during Post monsoon (-0.15±0.36).

The highest skewed at S.t 3 during Northeast monsoon might be influenced by low current action and accumulation with more fine particles. Meanwhile the lowest skewed in Post Monson can be associated with sediment deposited in the environment influenced by strong current action or as the results of accumulation of coarse grain at these areas as proposed by Buller and McManus (1979). According to Shahbuddin (1996), positive skew indicates an excess of fine grain sizes which could be due either to the addition of fine sediment to the deposits or to the selective removal of the coarser grains. In general, it can be pointing out that the sediments in Perlis River were predominated by coarse grains as most of are mostly ranging by negatively skewed. A statistical analysis by T-test clearly showed that there was have a no significant difference ($p>0.05$) in skewness between the season and stations.

To test this relationship further, correlation coefficients for the skewness and sorting against means size were calculated (Fig. 5). Both the skewness and kurtosis show a weak inverse correlation with the mean size (phi scale) as the R^2 =0.315 and 0.109 respectively) (Fig. 5A and B), indicating that the finer the grain size, the lower the skewness and sorting values.

A B

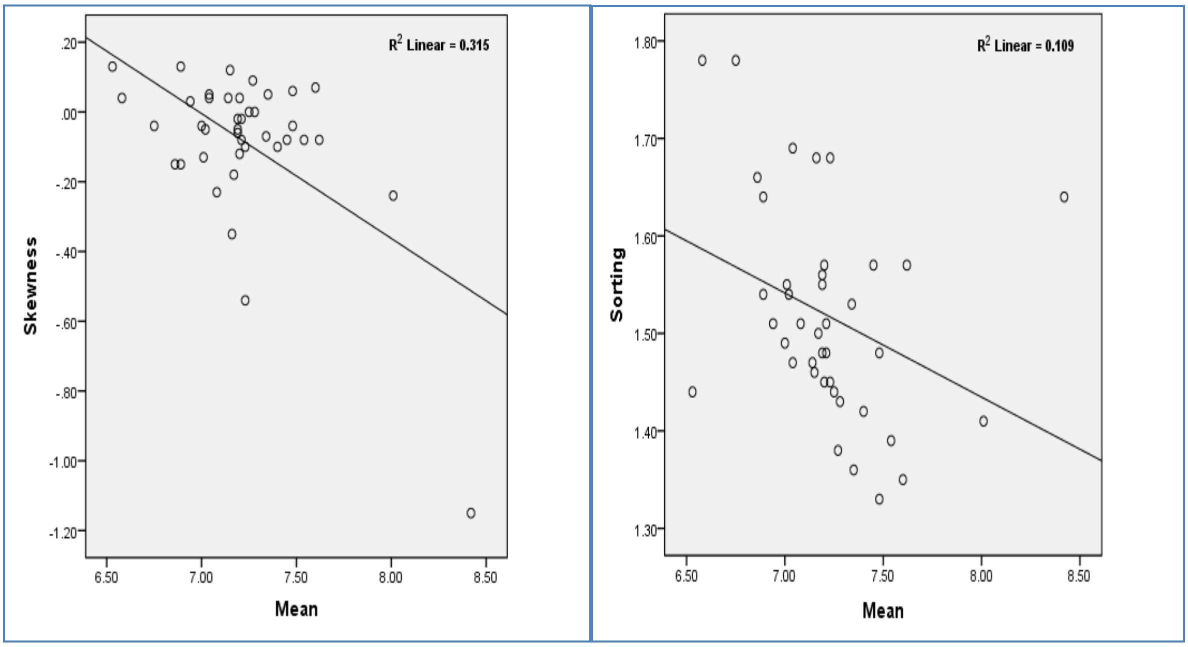

FIGURE 5 Correlation of mean size against sorting and skewness during various seasons

CONCLUSION

The sediment characteristics in the Perlis areas are not much influenced by the monsoons but play the role on the change of the distribution patterns of sediments. Influence from boating activities and human activities around the study area might be the main factors for the distribution pattern of sediment in the study area.

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Development of distributed energy systems in Middle East Countries

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Keywords: *Renewable, energy, Solar, Wind, Middle East, source*

Abstract:

Although Renewable energy applications in Middle East countries were started in the middle of the seventies, they have only gained momentum in the last ten years. Considering the past gained experience, a proposed national Renewable Energy (RE) plan aims toward bringing RE into the main stream of the national energy supply system with a target contribution of 10% of the electricity demand by the year 2020. The proposed plan calls for a wide spectrum of renewable energy applications.

This paper will highlight renewable energy applications in Middle East countries, the gained experience, the RE resources, and the future prospects for the utilization of RE recourses

Contents

1. Introduction:

Sustainable living is the kind of living by an individual or society which tries to reduce their dependence on Earth’s unreplenishable natural resources. Practitioners of sustainable living often attempt to reduce their carbon footprint by altering their modes of transport, energy consumption and other living habits including diet. Promoters of sustainable living aim to lead their lives in ways that are in tune with sustainability, in natural balance and with respect to mankind’s symbiosis with the Earth's natural ecology and cycles. The practice and general philosophy of ecological living is highly interrelated with the overall principles of sustainable development.

According to voluminous BP Statistical Review of World Energy 2012 has found that total 2011 energy consumption throughout the Middle East grew by 4.3% over 2010 consumption. The figures show that total energy consumption for last year stood at 747.5 million tonnes of oil equivalent, representing a 6.1% share of total energy consumption around the world. Out of the total energy consumed about 98.7% is produced from non-renewable or fossil sources like coal, oil and natural gas etc. Due to the fact that these non-renewable sources will get extinct in future, we will be forced to change to other energy generation techniques based on renewable sources. This is the only way to achieve an energy generation technique which is sustainable. So in this project we have tried to find a suitable solution that could satisfy Middle East’s need of renewable energy. At the end of the research we have found an amble solution. (Rühl 2008)

In Libya energy production is mainly from fuels like Oil and natural gas. From statistics energy production is dominated by Oil accounting 59% of total of total Libyan energy production in energy content terms. This is followed by natural gas with a share of 40% .But renewable sources represent only 1 %.This clearly shows the current trend in energy generation. The renewable sources such as hydro, wind, bioenergy, photovoltaic, wind, tidal, solar and thermal, all of these represent only 1% from the total energy production. (IEA & Taxes 2nd 2009).

According to Global Studies submitted by the German Aerospace Centre for technical possibilities and economic renewable energy sources in the countries of the Mediterranean basin, including Libya, that they have huge potential of renewable energy sources.

Although total reliance in Middle East is on fossil energy sources, because it provides these resources locally and considering that Middle East oil exporter. But on the other hand, Middle East has enormous sources of renewable energy represented by the solar radiation, wind, running water (hydro), and biomass, which must be studied and evaluated thoroughly to identify the potential of each source.

Therefore and as a result of some researches above, the objectives of this paper is to identify the possibility of using the renewable energy as a major energy source in Middle East countries. The main points of this study are:

- Identify renewable energy sources in Middle East and identify full potential for each.
- Identify the input and output value (less cost and more production).
- Reliability and sustainable for each sources.
- Identify the best renewable energy source that can be utilized in Middle East.

2. Literature review and Background:

The studies in field of electrical power in Middle East generation tended to make wider use of new energy sources and renewable energy. The new and renewable energy is one of the inexhaustible energies, because it depends on natural, where it does not produce any exhaust air pollution, so it is environment friendly.

According to Al-Zawia university research, the energy sector in one of Middle East countries showed a significant growth during the seventies and early eighties, particular fossil energy sources, such as oil and natural gas, where the annual growth rate was approximately 15%. Then this growth slightly decreased until the year 2000, where it began grow again. (Almaktoof 2010)

The renewable energy is almost non-existent. Wind energy have been used in the fifties contract to pump water in some areas is still some wind pumps to list now in some locations. Also uses charcoal for domestic heating at the moment. But there are no rates of Statistics for this source of non-commercial energy in the domestic energy system. Limited the use of renewable energy is currently small uses represented in the electrification of remote areas, water pump, and in the field of telecommunications, a total capacity is about 1865 wk. (Almaktoof 2010)

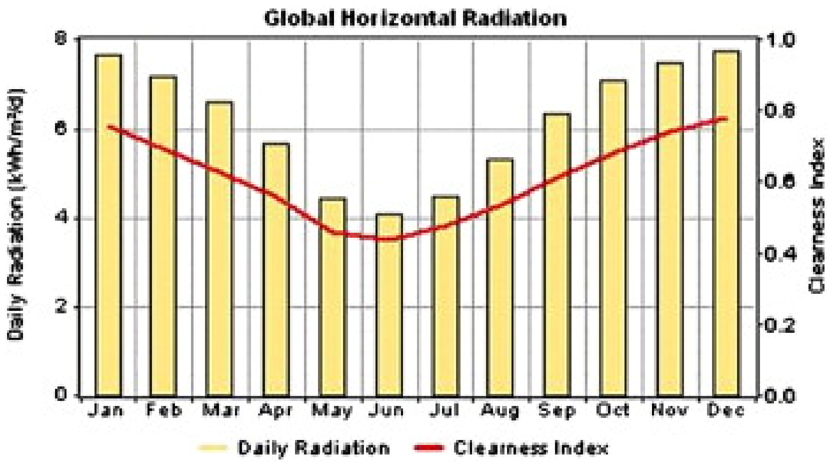
- **Solar:**

“Technologies harness the energy of solar irradiance to produce electricity using photovoltaic (PV) and concentrat-ing solar power (CSP), to produce thermal energy (heating or cooling, either through passive or active means), to meet direct lighting needs and, potentially, to produce fuels that might be used for transport and other purposes. The technology maturity of solar Applica tons ranges from R&D (e.g. Fuels produced from solar energy), to relatively mature (e.g., CSP), to mature (e.g. Passive and active solar heating, and wafer-based silicon PV).Many but not all of the technologies are modular in nature, allowing their use in both centralized and decentralized energy systems”. (Edenhofer, Ottmar; Pichs-Madruga, Ramón; Sokona, Youba; Seyboth, Kristin; Kadner, Susanne; Zwickel, Timm; Eickemeier, Patrick; Hansen, Gerrit; Schlömer, Steffen; von Stechow, Christoph; Matschoss, Patrick 2011).

Solar irradiation has been collected from NASA’s Surface meteorology and Solar Energy (SSE) resource website. (NASA surface meteorology and solar Energy) Currently, roughly 1368 watt per square meter (W/m2) of solar energy on average illuminates the disk shaped profile of the outermost atmosphere of the Earth. This is called the solar constant S, although its value does vary slightly with sunspot activity cycles/changes, Earth's changing orbital distance from the Sun and other factors. Earth absorbs around 70% of this Total Solar Irradiance (TSI) and the rest is reflected into space (SORCE), and only 58% of the TSI intercepted by the Earth reaches the surface after accounting for atmospheric absorption. The total solar energy production available from the Sun at the Earth's surface over time is given in equation. (Ron Nielsen)

E=0.58*3.6*10−9Snπr2 → 1

Where E is the solar energy in EJ, S is the solar constant in W/m2, n is the number of hours and r is the Earth's radius in Km.
Daily solar irradiation data were imported into HOMER to calculate daily radiation and monthly average values of clearness index. Fig 2 demonstrates the average daily radiation for each month in kWh/m2 per day and the monthly clearness index curve over the whole year. It shows that solar irradiation is high from October to February. Considering the radiation variation, the sensitivity analysis is done with five values around the mean radiation. Solar radiation data have been used in the proposed hybrid model as an input resource.



Resource: NASA surface meteorology and solar Energy, [Online Available]: http://eosweb.larc.nasa.gov/sse/RETScreen/, [Accessed March. 29, 2013]

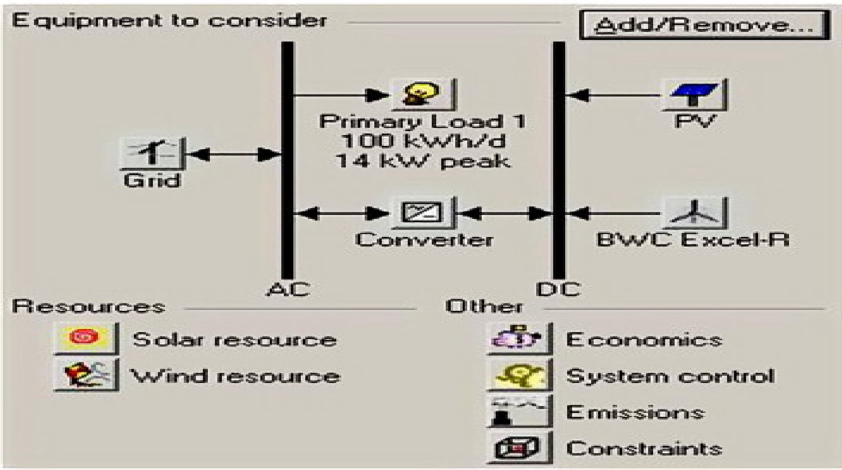
Figure 1 Daily solar radiations with clearness index

According to some recent research of NASA, one of Middle East countries has a solar potential is even greater than the petroleum productivity. If it used just 0.1% of its landmass for solar power, it could generate the equivalent of seven million barrels of oil per day, which would be about five times the 1.4 million barrels it currently produces. Some of solar power engineers say it takes a lot of space; However the Middle East countries have enough open space (desert). So there are wide lands for solar power installations.

- **Hydro:**

“Hydropower harnesses the energy of water moving from higher to lower elevations, primarily to generate electricity. Hydropower projects encompass dam projects with reservoirs, run-of-river and in-stream projects and cover a continuum in project scale. This variety gives hydropower the ability to meet large centralized urban needs as well as decentralized rural needs. Hydropower technologies are mature. Hydropower projects exploit a resource that varies temporally. However, the controllable output provided by hydropower facilities that have reservoirs can be used to meet peak electricity demands and help to balance electricity systems that have large amounts of variable Regeneration. The operation of hydropower reservoirs often reflects their multiple uses, for example, drinking water. Irrigation, flood and drought control and navigation, as well as energy supply”. (Edenhofer, Ottmar; Pichs-Madruga, Ramón; Sokona, Youba; Seyboth, Kristin; Kadner, Susanne; Zwickel, Timm; Eickemeier, Patrick; Hansen, Gerrit; Schlömer, Steffen; von Stechow, Christoph; Matschoss, Patrick 2011).

The major components of the grid-connected hybrid system are PV or wind turbines, or both PV and wind turbines, and a power converter. For economic analysis, the number of units to be used, capital costs, replacement and O&M costs, and operating hours have to be defined in HOMER in order to simulate the system. Fig. 6 represents a typical hybrid energy system. (Shafiullah et al. 2012)



Resource: NASA surface meteorology and solar Energy, [Online Available]: http://eosweb.larc.nasa.gov/sse/RETScreen/, [Accessed March. 29, 2013]

Figure 2 represents a typical hybrid energy system

- **Wind:**

“Wind energy harnesses the kinetic energy of moving air. The primary application of relevance to climate change mitigation is to produce electricity from large wind turbines located on land (onshore) or in sea- or freshwater (offshore).Onshore wind energy technologies are already being manufactured and deployed on a large scale. Offshore wind energy technologies have greater potential for continued technical advancement. Wind electricity is both variable and, to some degree, unpredictable, but experience and detailed studies from many regions have shown that the integration of wind energy generally poses no insurmountable technical barriers”.

(Edenhofer, Ottmar; Pichs-Madruga, Ramón; Sokona, Youba; Seyboth, Kristin; Kadner, Susanne; Zwickel, Timm; Eickemeier, Patrick; Hansen, Gerrit; Schlömer, Steffen; von Stechow, Christoph; Matschoss, Patrick 2011).
Wind speed has been collected from NASA's SSE resource website (NASA surface meteorology and solar Energy). The data was collected with a standard anemometer of height 10 m, however, in order to produce efficient wind energy, wind speeds at heights greater than 10 m are required. The popular power law is used to derive the hub height wind speeds at various potential sites is given in equation.

$$\frac{v_2}{v_1} = (\frac{z_2}{z_1})$$

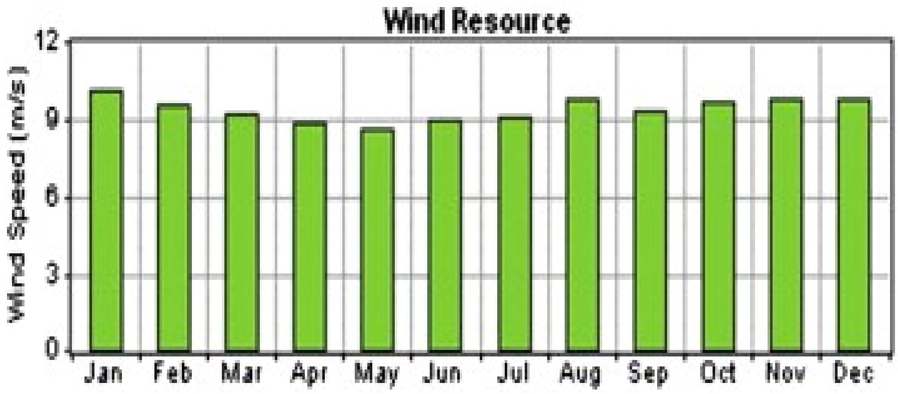
Where v_2 is the extrapolated wind speed at height z_2 and v_1 is the measured wind speed at z_1. The exponent α depends on the nature of the roughness of the surface, wind speeds and temperature. An exponent value of 0.14 or (1/7) has been widely chosen as a good representation of the prevailing conditions. Power production from wind turbines is dependent on wind speed (v), density of the air (ρ) and the swept area of the rotor (A). Therefore, the maximum power P available from the wind can be represented as equation. (J.N. Kamau, R. Kinyua, J.K. Gathua).

$$P = \frac{1}{2}\rho A v^3$$

However, the actual amount of energy production will be less as it is not possible to extract all available energy by the turbine and therefore a power coefficient (Cp) is defined. The ideal or maximum theoretical efficiency Cp of a turbine is the ratio of maximum power obtained from the wind to the total available power in the wind. The factor Cp = 0.593 is known as Betz's coefficient or limit (B. Fox, D. Flynn, L. Bryans, N. Jenkins, D. Millsboro, M. O'Malley et al).
Standard atmospheric density can be measured as per reference. (Digital Dutch)
In this paper, standard atmospheric density has been assumed as 1.1217 kgm−3 to calculate the total wind power.

From equation: $P = \frac{1}{2}\rho A v^3$

It is seen that wind speed has a significant role in the amount of energy that can be produced from a wind source. In the proposed hybrid model wind speed data (m/s) were imported into HOMER to be synthesized based on a Weibull factor of k = 1.74, auto correlation factor = 0.901, and diurnal pattern strength = 0.0271. Figure 3 shows that wind speed varies between 8.7 m/s and 9.3 m/s and depends on seasonal conditions.

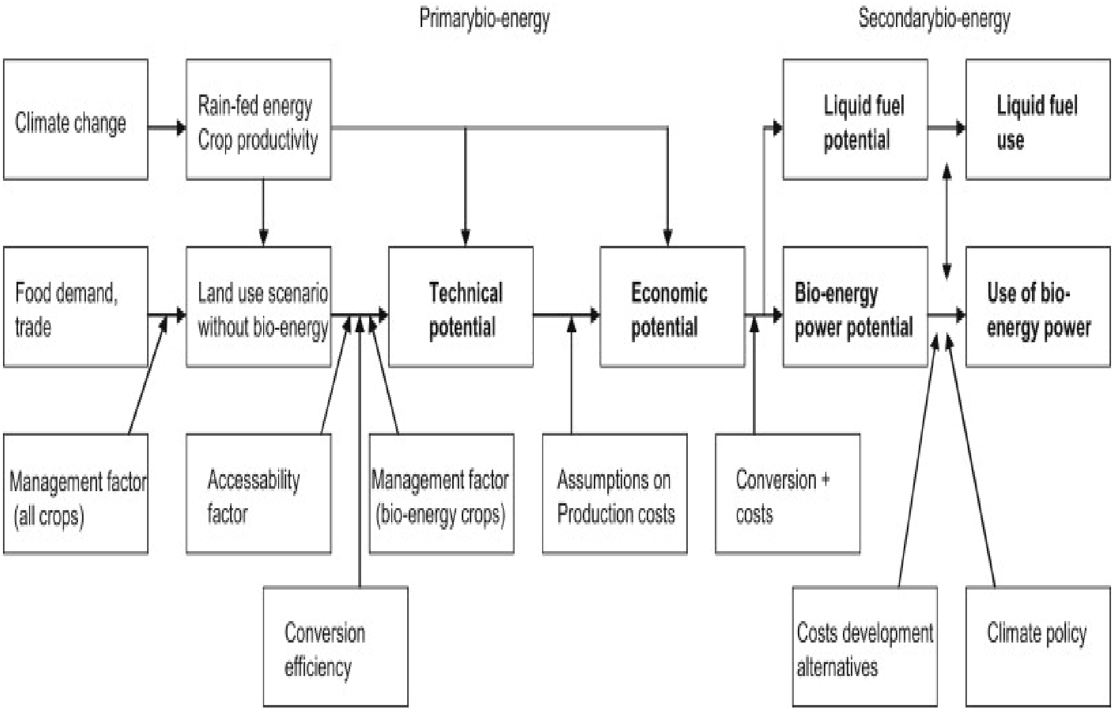


Resource: NASA surface meteorology and solar Energy, [Online Available]: http://eosweb.larc.nasa.gov/sse/RETScreen/, [Accessed March. 29, 2013]

3 Figure Monthly wind speed variations

- **Bioenergy**

"Bioenergy can be produced from a variety of biomass feedstock, including forest, agricultural and livestock residues; short-rotation forest plantations; energy crops; the organic component of municipal solid waste; and other organic waste streams. Through a variety of processes, this feedstock can be directly used to produce electricity or heat, or can be used to create gaseous, liquid or solid fuels. The range of bioenergy technologies is broad and the technical maturity varies substantially. Some examples of commercially available technologies include small- and large-scale boilers; domestic pellet based heating systems and ethanol production from sugar and starch. Advanced biomass integrated gasification combined-cycle power plants and lignocellulose-based transport fuels are examples of technologies that are at a pre-commercial stage, while liquid biofuel production from algae and some other biological conversion approaches are at the research and development (R&D) phase. Bioenergy technologies have applications in centralized and decentralized settings, with the traditional use of biomass in developing countries being the most widespread current application. Bioenergy typically offers constant or controllable output. Bioenergy projects usually depend on local and regional fuel supply availability, but recent developments show that solid biomass and liquid biofuels are increasingly traded internationally". (Edenhofer, Ottmar; Pichs-Madruga, Ramón; Sokona, Youba; Seyboth, Kristin; Kadner, Susanne; Zwickel, Timm; Eickemeier, Patrick; Hansen, Gerrit; Schlömer, Steffen; von Stechow, Christoph; Matschoss, Patrick 2011).



Resource: NASA surface meteorology and solar Energy, [Online Available]: http://eosweb.larc.nasa.gov/sse/RETScreen/, [Accessed March. 29, 2013]

Figure 4 Methodology of assessing bio-energy potentials ((Van Vuuren, van Vliet & Stehfest 2009)

The biomass energy in Middle East countries has remained unexplored to a great extent, although tremendous renewable energy potential in the form of Bioenergy. Municipal solid wastes represent the best source of biomass in the Middle East. The high rate of population growth, urbanization and economic expansion in the region is not only accelerating consumption rates but also accelerating the generation of municipal waste. "The gross urban waste generation quantity from Middle East countries is estimated at more than 150 million tons annually". (S Zafar)

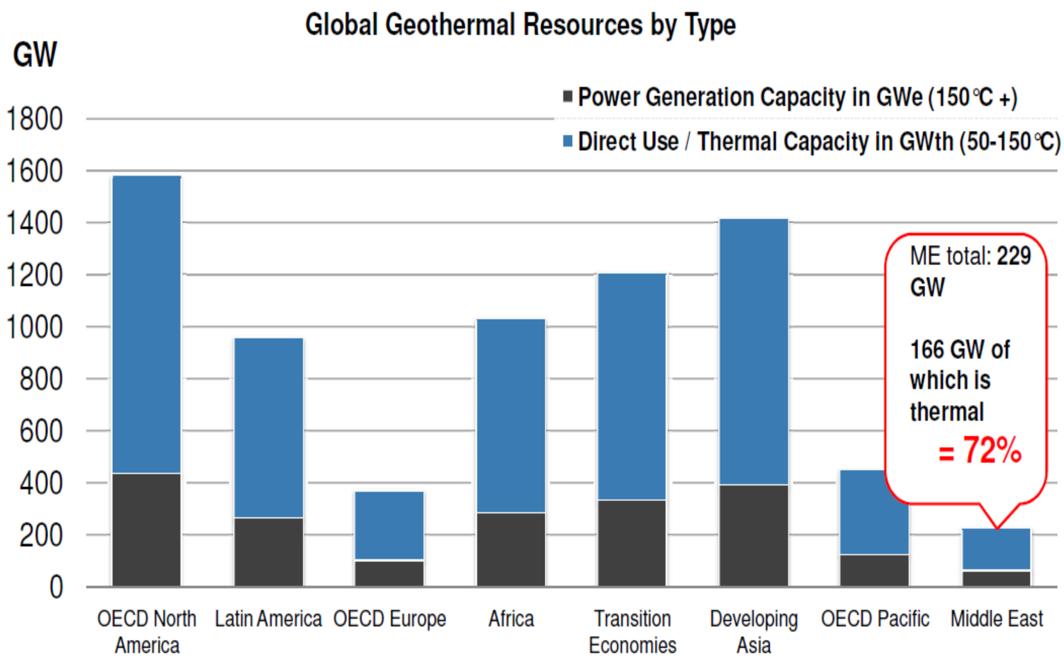
In Middle East countries, huge quantity of sewage sludge is produced on daily basis which presents a serious problem due to its high treatment costs and risk to environment and human health. According to estimates from the Drainage and Irrigation Department of Dubai Municipality On an average, the rate of wastewater generation is 80-200 liters per person each day and sewage output is rising by 25 percent every year, sewage generation in the Dubai increased from 50,000 m3 per day in 1981 to 400,000 m3 per day in 2006. The food processing industry in Middle East produces a large number of organic residues and by-products that can be used as biomass energy sources. In recent decades, the fast-growing food and beverage processing industry has remarkably increased in importance in major countries of the Middle East. Since the early 1990s, the increased agricultural output stimulated an increase in fruit and vegetable canning as well as juice, beverage, and oil processing in countries like Egypt, Syria, Lebanon and Saudi Arabia. There are many technologically-advanced dairy products, bakery and oil processing plants in the region.

Agriculture plays an important role in the economies of most of the countries in the Middle East. The contribution of the agricultural sector to the overall economy varies significantly among countries in the region, ranging, for example, from about 3.2 precent in Saudi Arabia to 13.4 precent in Egypt. Large quantities of crop residues are produced annually in the region, and are vastly underutilised. Current farming practice is usually to plough these residues back into the soil, or they are burnt, left to decompose, or grazed by cattle. These residues could be processed into liquid fuels or thermochemical processed to produce electricity and heat in rural areas. Energy crops, such as Jatropha, can be successfully grown in arid regions for biodiesel production. In fact, Jatropha is already grown at limited scale in some Middle East countries and tremendous potential exists for its commercial exploitation.

The Middle Eastern countries have strong animal population. The livestock sector, in particular sheep, goats and camels, plays an important role in the national economy of the Middle East countries. Many millions of live ruminants are imported into the Middle Eastern countries each year from around the world. In addition, the region has witnessed very rapid growth in the poultry sector. The biogas potential of animal manure can be harnessed both at small- and community-scale. (Salman Zafar 2013)

- **Geothermal:**

“Geothermal energy utilizes the accessible thermal energy from the Earth's interior. Heat is extracted from geothermal reservoirs using wells or other means. Reservoirs that are naturally sufficiently hot and permeable are called hydrothermal reservoirs, whereas reservoirs that are sufficiently hot but that are improved with hydraulic stimulation are called enhanced geothermal systems (EGS). Once at the surface, fluids of various temperatures can be used to generate electricity or can be used more directly for applications that require thermal energy, including district heating or the use of lower-temperature heat from shallow wells for geothermal heat pumps used in heating or cooling applications. Hydrothermal power plants and thermal applications of geothermal energy are mature technologies, whereas EGS projects are in the demonstration and pilot phase while also undergoing R&D. When used to generate electricity, geothermal power plants typically offer constant output”.(Edenhofer, Ottmar; Pichs-Madruga, Ramón; Sokona, Youba; Seyboth, Kristin; Kadner, Susanne; Zwickel, Timm; Eickemeier, Patrick; Hansen, Gerrit; Schlömer, Steffen; von Stechow, Christoph; Matschoss, Patrick 2011).



Source: *IPCC 2012 and calculations of Icelandic Geological Survey - ISOR January 2012, IPCC 2012, Valgardur Stefansson (2005) and calculations of Icelandic Geological Survey - ISOR June 2012.*

Figure 12 Global Geothermal Resources by Type

3. The possible sources of renewable energy in Middle East countries:

- Solar
- Hydro
- Wind
- Bioenergy
- Geothermal

4. Materials and Methods:

In order to achieve the objectives mentioned above, the methodology and approach to carry out the research will include:

Conduct feasibility study to identify renewable energy sources in Middle East countries:

4.1 Data

In order to obtain accurate results of this paper, should study the overall rate of current energy consumption in some Middle East countries.

According to the database of Libyan General Organization for Electricity, that shows the rates of energy consumption in Libya, the Average annual energy consumption in the year 2010 attained 73,237,772 MWH. (Annual Report 2010)

The table below shows the amount of energy consumed in 2010:

Table 1 Shown Amount of Energy Consumed

Types of consumption	The number of consumers accounts	The amount of consumption MWH	Average
Residential	889,447	6,422,881	%31.18
Agricultural	110,852	2,197,685	%10.66
Made River	12	625,613	%3.04
Industrial	32,533	2,078,255	%10.09
Commercial	140,450	2,694,283	%13.08
Public facilities	6,498	2,406,443	%11.68
Public Lighting	18,376	3,996,020	%19.4
Desalination stations	8	181,033	%0.88
Total	1,198,176	20,602,217	%100

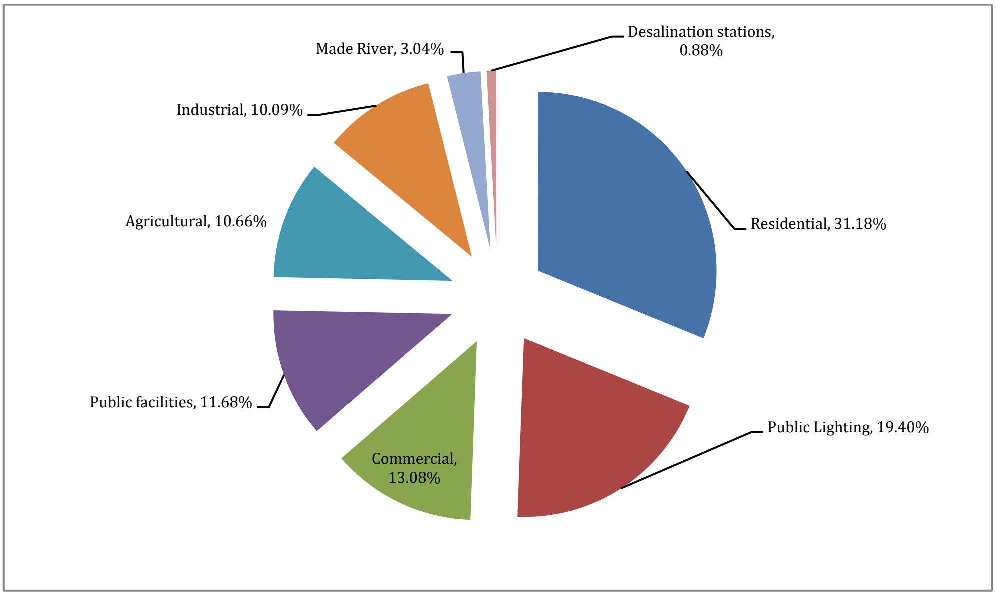


Figure 5 Average of Consumption in Middle East countries

Average cost of a Kilowatt-hour produced = 0.0306 LYD/KWH = 0.02 $/KWH

Average cost of a Kilowatt-hour produced = 0.02 * 1000 = 20 $/MWH

Total annual cost of consumption US$= 20,602,217 * 20 = 412,044,340 US $

4.2 Solar

4.2.1 Estimation of monthly average solar radiation in Middle East countries:

Many models have been used for the prediction of the amount of solar energy incident on a horizontal surface. One of the simplest, which also gives the smallest percentage error for the estimation of the monthly average daily global solar radiation, is the well-known Angstrom correlation (Kreider and Kreith, 1991; Duffie and Beckman, 1991) which can be written in the form: $\overline{H} = H_o(a + b\overline{n}/N)$

Where:

$\overline{H}$ Is the monthly average of daily global solar radiation on a horizontal surface (kWh m-2 day-1)

Ho is the extra-terrestrial solar radiation on a horizontal surface on an average day of each month (kWh m-2 day-1),

N Is the monthly mean daily number of hours of observed bright sunshine.

$\overline{n}$ Is the mean daily number of hours of daylight in a given month between sunrise and sunset, and a and b are regression coefficients.

Where:

$N = 2/15\omega_{s,}$

$$H_o = \frac{24I_{sc}}{\pi}[1 + 0.033\cos(360\,\overline{n}/365)] \times [\cos\phi\cos\delta\sin\omega_s + \frac{\pi\omega_s}{180}\sin\emptyset\sin\delta],$$

$$\omega_s = \cos^{-1}[-\tan\emptyset\cos\delta]$$

And

$$\delta = 23.45\sin[360(284 + \overline{d})/365].$$

Where:

$I_{sc}(1.367\ \mathrm{KW\ m^{-2}})$ ➔ Is the solar constant.

ω_s ➔ Is the sunset hour angle in degrees?

δ➔ Is the declination in degrees?

$\overline{d}$ ➔ Is the average its day of the month.

$\emptyset$ ➔ Is the latitude angle in degrees?

Table 2 Average values of $\bar{H}/H_o$ in Middle East countries

Station	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Station 1	0.534	0.582	0.590	0.597	0.584	0.615	0.640	0.616	0.612	0.558	0.549	0.461
Station 2	0.418	0.432	0.479	0.545	0.558	0.603	0.599	0.596	0.533	0.504	0.474	0.394
Station 3	0.514	0.529	0.565	0.593	0.587	0.612	0.635	0.626	0.628	0.581	0.546	0.448
Station 4	0.546	0.573	0.571	0.595	0.581	0.623	0.613	0.602	0.622	0.584	0.589	0.518
Station 5	0.614	0.653	0.653	0.658	0.614	0.635	0.675	0.681	0.612	0.565	0.569	0.595
Station 6	0.683	0.676	0.678	0.651	0.627	0.628	0.664	0.680	0.663	0.696	0.643	0.610
Station 7	0.636	0.660	0.653	0.664	0.654	0.681	0.688	0.683	0.679	0.678	0.647	0.625
Station 8	0.591	0.597	0.578	0.608	0.602	0.628	0.638	0.640	0.638	0.617	0.604	0.569
Station 9	0.608	0.632	0.624	0.651	0.621	0.646	0.653	0.645	0.621	0.647	0.615	0.616
Station10	0.660	0.651	0.645	0.650	0.612	0.654	0.662	0.664	0.692	0.713	0.705	0.665
Station11	0.652	0.669	0.660	0.671	0.671	0.678	0.665	0.682	0.673	0.698	0.685	0.629
Total	**6.457**	**6.655**	**6.688**	**6.875**	**6.710**	**6.996**	**7.128**	**7.106**	**6.963**	**6.842**	**6.622**	**6.127**
Average	**0.587**	**0.605**	**0.608**	**0.625**	**0.610**	**0.636**	**0.648**	**0.646**	**0.633**	**0.622**	**0.602**	**0.557**

The average values of $\bar{H}/H_o$ and of $\bar{n}/N$ for each month are computed for each station and are displayed in Tables 2 and 3, respectively. Been applied the method of least squares on the mean monthly values of $\bar{H}/H_o$ and $\bar{n}/N$ for eleven stations. The regression equations obtained are given in Table 4.

Table 3 Average values of $\bar{n}/N$ for the period (1981 to 1988)

Station	Month											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Station 1	0.606	0.650	0.668	0.665	0.662	0.766	0.844	0.838	0.807	0.711	0.623	0.565
Station 2	0.498	0.496	0.566	0.643	0.694	0.782	0.852	0.838	0.729	0.684	0.552	0.533
Station 3	0.594	0.593	0.643	0.664	0.710	0.832	0.861	0.866	0.820	0.766	0.659	0.606
Station 4	0.651	0.702	0.707	0.722	0.726	0.834	0.882	0.884	0.849	0.791	0.728	0.647
Station 5	0.754	0.759	0.748	0.701	0.675	0.696	0.864	0.874	0.786	0.742	0.772	0.744
Station 6	0.816	0.800	0.790	0.745	0.725	0.766	0.874	0.882	0.831	0.782	0.778	0.769
Station 7	0.748	0.793	0.730	0.774	0.787	0.803	0.903	0.909	0.860	0.856	0.827	0.781
Station 8	0.744	0.770	0.696	0.745	0.711	0.824	0.893	0.875	0.857	0.783	0.770	0.704
Station 9	0.759	0.775	0.734	0.754	0.775	0.873	0.913	0.915	0.871	0.854	0.819	0.685
Station10	0.790	0.739	0.724	0.766	0.743	0.827	0.890	0.895	0.836	0.804	0.825	0.794
Station11	0.828	0.838	0.782	0.826	0.825	0.891	0.926	0.927	0.895	0.907	0.899	0.827

The low values of the probability levels listed in Table 4 indicate statistically significant regression of $\bar{H}/H_o$ on $\bar{n}/N$ for all stations apart from Station 10, for which further investigation should be carried out equation $\bar{H}/H_o = a + b\,\bar{n}/N$.

Table 4 Values of a and b in the regression

Station	Latitude	Longitude	Height l.s.a	Number of months	Intercept a	Slope b	Correlation coefficient R	.Prob level
Station 1	54°32'N	11°13'E	m 030	96	0.267180	0.444286	0.675533	0.00000
Station 2	49°32'N	51°21'E	m 626	86	0.180035	0.506928	0.845887	0.00000
Station 3	06°32'N	09°20'E	m 039	84	0.350527	0.319205	0.571125	0.00000
Station 4	43°30'N	10°20'E	m 011	95	0.342277	0.319683	0.458041	0.00000
Station 5	23°30'N	35°13'E	m 505	83	0.445693	0.243581	0.341525	0.00158
Station 6	08°30'N	30°09'E	m 331	81	0.386953	0.345767	0.422536	0.00009
Station 7	45°29'N	32°24'E	m 003	90	0.453871	0.257145	0.583058	0.00000
Station 8	08°29'N	57°15'E	m 265	77	0.405312	0.261203	0.555501	0.00000
Station 9	02°29'N	34°21'E	m 065	89	0.489151	0.176613	0.344961	0.00093
Station10	01°27'N	26°14'E	m 437	89	0.559291	0.130769	0.107205	0.31733
Station11	13°24'N	18°23'E	m 408	91	0.389250	0.322792	0.463893	0.00000

4.2.2 Availability of Solar in Middle East compared to Australia:

The Monthly mean daily global solar exposure is the average of all available daily exposure for the month. The Daily global solar exposure is the total solar energy for a day falling on a horizontal surface. It is measured from midnight to midnight. The values are usually highest in clear sun conditions during the summer and lowest during winter or very cloudy days. (Australian government Bureau of Meteorology)

Table 2 below shows overall rate of global solar exposure for Australia and Middle East countries. Unit used is kWh m-2

Table 5 overall rate of global solar exposure for Australia and Middle East countries

Country	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Australia	7.8	6.9	5.8	4.3	3.0	2.5	2.7	3.6	4.8	6.1	7.2	7.7	**5.2**
Middle East	6.5	6.7	6.7	6.9	6.7	6.9	7.1	7.1	6.9	6.8	6.6	6.1	**6.8**

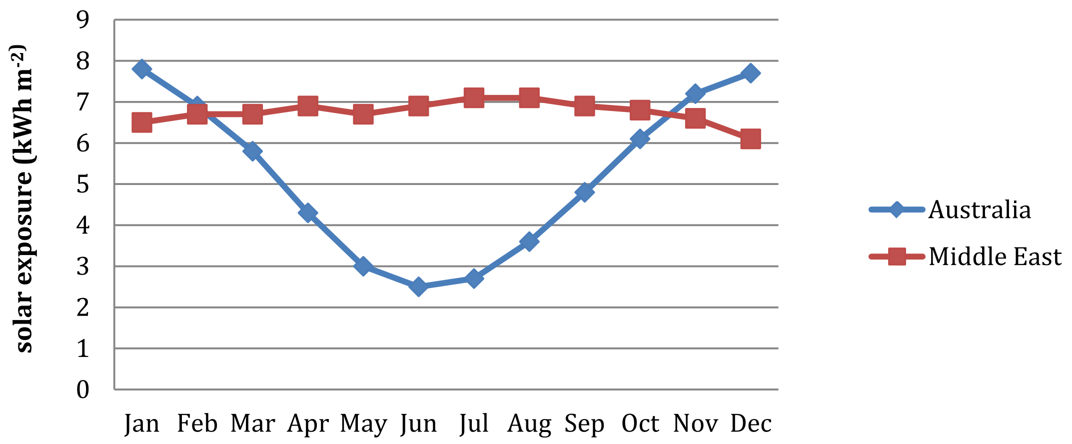


Figure 6 overall rate of global solar exposure for Australia and Middle East countries

4.2.3 Strategies:

To identify the strategies of this type of energy should analyse the input or income values and output values. Times hours of usable light (5 is a normal number) The sun may be up 12 hours a day in the summer, but the 3 morning and 3 evening hours, carry little power, so you can't count them. According to the National Renewable Energy Laboratory, there's a possibility to generate a solar energy. Solar energy expected as their experiences laboratory is shown at the table 5:

Table 6 Solar energy expected in one of Middle East countries as their experiences laboratory

Resource	Value	Units	Period
Solar Potential	5,976,855,697	year/MWh	2008

"These estimates are derived from the best available solar resource datasets available to NREL by country. These vary in spatial resolution from 1 km to 1 degree (approximately 100 km) depending on the data source. High spatial resolution datasets (1 km to 40 km cells) were modelled to support country or regional projects. Where high resolution datasets were not available, data from NASA's Surface Meteorology and Solar Energy (SSE) version 6 databases were used. The data represents total potential solar energy per year as a function of land area per solar class (KWh/m²/day). Each solar class correlates to a specific 0.5 kWh/m²/day range. Energy is calculated by multiplying the productive land by the class, conversion efficiency and number of days per year. In this case, a standard calendar year of 365 days was used. The conversion efficiency rate applied was 10%. (E = Productive Land * kWh/m²/day * 365 days * 10% efficiency). The solar data has been derived from solar data measured or modelled between 1961 and 2008, depending on the dataset." (National Renewable Energy Laboratory)
As we can see in the result of researches above, and as a Middle East countries space: There is high possibility to Generate about 5,976,855,697 MWH/year from Solar only in one of those countries.

4.3 Wind

4.3.1 Wind Resources by Class per Country at 50m:

The estimates shown at (Table 6) are derived from a composite of high resolution wind resource datasets modelled for specific countries with low resolution data originating from the National Centres for Environmental Prediction (United States) and the National Centre for Atmospheric Research (United States) as processed for use in the IMAGE model. The high resolution datasets were produced by the National Renewable Energy Laboratory (United States), Risø DTU National Laboratory (Denmark), the National Institute for Space Research (Brazil), and the

Canadian Wind Energy Association. The data represents wind power class intervals 3 through 7 at 50 m height above ground. Wind class is derived from the capacity factor obtained from the 20% Wind Energy by 2030 Table B-10. The range was created from years 2005 and 2010.

Table 7 Wind Resources by Class per Country at 50m

Country	Total Resource Area at (2^km) Classes ,m50 7-3	Rank	Resource Area ,m50 at (2^km) 3Class	Resource Area ,m50at (2^km) 4Class	Resource Area ,m50at (2^km) 5Class	Resource at (2^km)Area Wind Classes ,m50 7&6
Brazil	3225342	1	1,225,289	754,534	517,807	727,712
Canada	2712417	2	1,357,662	635,789	294,430	424,536
USA	2237436	3	1,215,534	644,207	192,476	185,218
Russia	1152810	4	740,568	331,982	77,476	2,784
China	650882	6	366,922	167,383	66,893	49,684
Australia	417658	8	339,143	78,515	0	0
UK	146936	13	32,208	34,405	56,567	23,755
Germany	15377	27	7,811	6,151	1,391	23
Morocco	2302	52	2,302	0	0	0
UAE	813	61	540	179	61	33
Algeria	0	73	0	0	0	0
Egypt	0	104	0	0	0	0
Libya	0	136	0	0	0	0
Saudi Arabia	0	169	0	0	0	0
Serbia	0	171	0	0	0	0
Singapore	0	173	0	0	0	0
Yemen	0	207	0	0	0	0
Zambia	0	208	0	0	0	0
Zimbabwe	0	209	0	0	0	0

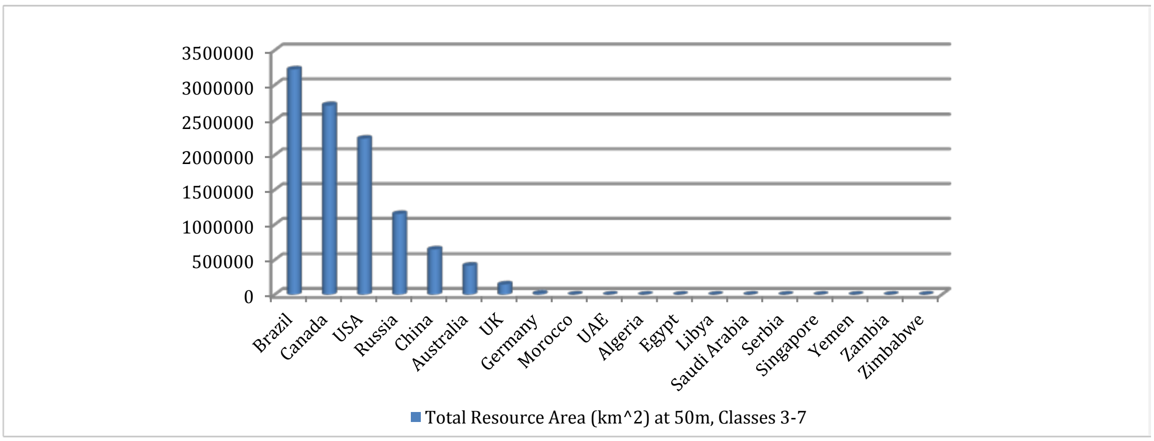


Figure 7 the global Wind Generation by Class per Country at 50m

As a result of the above research, also as a result of the percentage of wind power at 50 m height above ground in Middle East countries. The wind Energy is very low in that's countries compared to other countries, and that does not meet the needs of the consumer from daily energy. In addition, possibility to decline of activity winds during the quiet and stability days that will negatively effect on rate of energy generation.

4.3.2 Availability of wind energy in Middle East compared to Australia:

Middle East wind speed average: According to Centre for Solar and Wind Energy Research and Studies (CSERS) (located in Libya), Renewable energy R&D organization (located in Egypt), Saudi Arabian Meteorological Department, Algerian Meteorological Department and Sudan Meteorological Department, were collect the wind data available from 16 meteorological stations in Middle East countries at 10, 50 and 100 meters above sea level, for ten years and these information shown in the form of tables and graphs:
Table 8 shown below represents the average wind speed at three different levels; In general the average wind speed in Middle East countries is between (4 m/s to 8 m/s). (H.I.ABUSANNUGA&O.F.BADRI).

Table 8 the average wind speed at three different levels in 16 different places in Middle East countries

Station	Latitude	Longitude	Above see (m)level	wind Average speed at 10) (s/m) (meter	Average wind speed at (meter 50) (s/m)	Average wind speed at 100) (s/m) (meter
Station 1	34°45	12°05	3	5.2	8.8	9
Station 2	34°13	12°35	23	4.4	7.1	9.5
Station 3	33°02	13°09	80	5.7	7.7	8.1
Station 4	33°08	16°35	13	4.2	7.6	9.9
Station 5	32°01	20°10	6	6.5	8.8	9.8
Station 6	32°52	20°16	38	5.7	9	9.4
Station 7	31°47	22°34	25	5.4	8.4	10.6
Station 8	31°08	23°55	50	6.2	8.2	10.4
Station 9	30°49	21°15	625	7.3	9.5	9.8
Station 10	30°08	30°09	357	6	7.4	8.3
Station 11	29°52	10°59	621	7.4	8	9.7
Station 12	27°01	14°26	432	7.2	7.2	8.1
Station 13	26°18	15°57	267	5.9	5.9	8.8
Station 14	26°02	21°34	59	6.3	6.8	6.9
Station 15	24°13	23°18	435	5.8	5.6	9
Station 16	23°14	24°32	-2	5.8	7.5	5.9

As we can see, the higher speed of wind located on station 7. Latitude: 32 □47. Longitude: 22 34 Speed: 9.4 m/s.

On the other hand, the lowest speed located on station 16. Latitude: 29 □45. Longitude: 24 32. Speed: 5.5 m/s.
The average wind speed of selected stations from Middle East countries is:

$$\frac{123.5}{16} = 7.71 \text{ m/s}$$

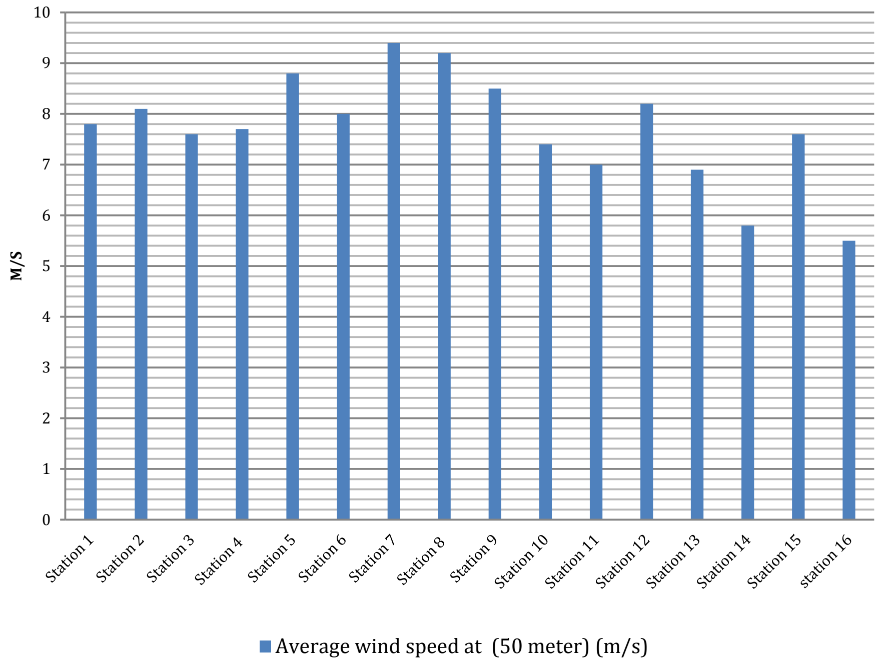


Figure 8 average wind speeds in 16 different places in Middle East countries.

Australia wind speed average: According to Bureau of Meteorology (Australian Government), also by using HOMER simulation which I have done during laboratory experiment as Figure 10, the amount of wind that Australia's major cities average over a year is listed below.
Table 9 gives the average annual wind speeds in kilometres per hour (KPH) for morning and afternoon. Morning wind speed readings are taken at 9:00 am local time, while afternoon winds are at 3:00 pm. The wind statistics here are long-term historical averages of weather data collected during 1981 to 2010.

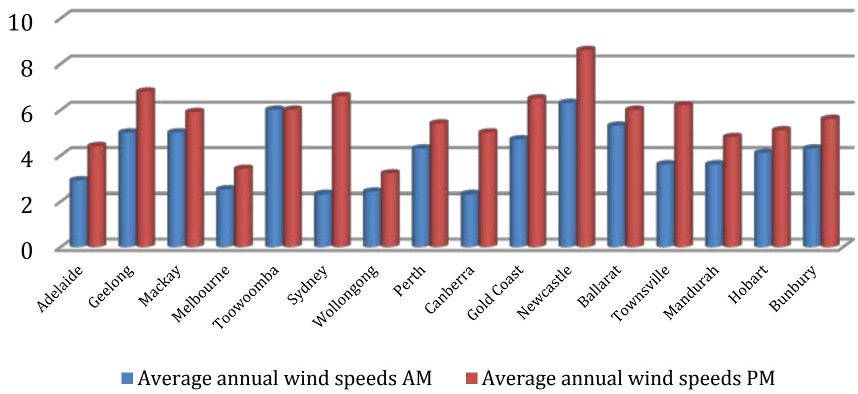


Figure 9 annual average wind speeds in different zones in Australia

Table 9 annual average wind speeds in different zones in Australia

Station	**Average annual wind speeds m/s**		
	AM	PM	Average
Adelaide	2.9	4.4	3.7
Geelong	5	6.8	5.9
Mackay	5	5.9	5.45
Melbourne	2.5	3.4	3
Toowoomba	6	6	6
Sydney	2.3	6.6	4.5
Wollongong	2.4	3.2	2.8
Perth	4.3	5.4	4.9
Canberra	2.3	5	3.7
Gold Coast	4.7	6.5	5.6
Newcastle	6.3	8.6	7.5
Ballarat	5.3	6	5.7
Townsville	3.6	6.2	4.9
Mandurah	3.6	4.8	4.2
Hobart	4.1	5.1	5
Bunbury	4.3	5.6	5

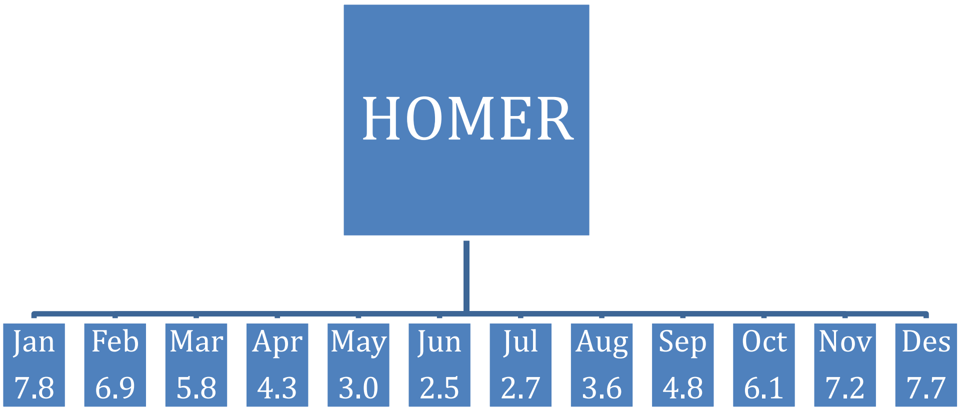


Figure 10 Estimation of monthly average solar radiation in Australia using HOMER simulation

As a database and tables above we can compare the rate of annul availability of wind between Australia and Middle East countries.
Figure 9 showing the average wind speed in Australia and Middle East, and Figure 10 showing the comparison of wind speed between some areas in Middle East and some Australia areas.

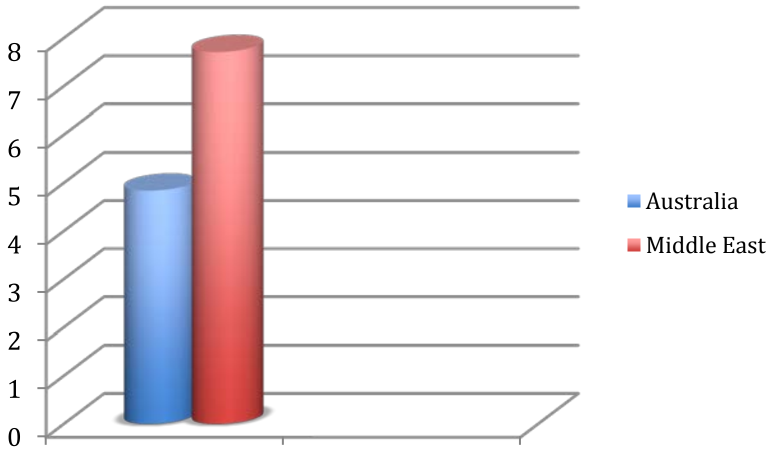
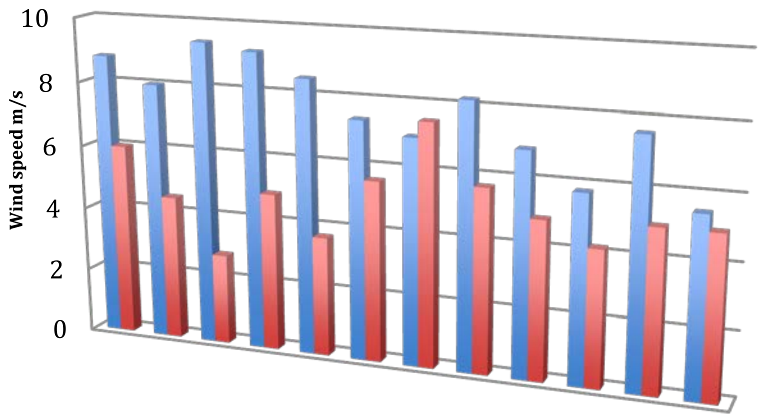


Figure 11 Average of wind speed in Middle East and Australia



Middle East	8.8	8	9.4	9.2	8.5	7.4	7	8.2	6.9	5.8	7.6	5.5
Australia	6	4.5	2.8	4.9	3.7	5.6	7.5	5.7	4.9	4.2	5	5

Figure 12 Wind speed in Middle East and Australia

5. Discussion:

As depicted in figure 11, both solar and wind energy considered great sources of energy in Middle East countries as a result of open places plenty, where the availability or solar plenty is about 6.8 KWh m, as a total average. the main reason for that is because the daily solar exposure rate is approximately the same level at most of year seasons, Can record a decline solar in cloudy winter specially on the coast of Mediterranean, where the total average of solar in winter on the coast about 6.1 KWh m in December and 6.4 in January, while the average of solar availability are increasing in the desert and far away from the coast, it usually be at the same level all year about 7 KWh m as shown in the figure 3. On the other hand, in Australia the availability of solar energy depend on the year times, where the average of solar availability about 2.5 KWh m in coast at January and about 7.8 KWh m in insides., and the annual total average in Australia approximately 5.2 KW h m.

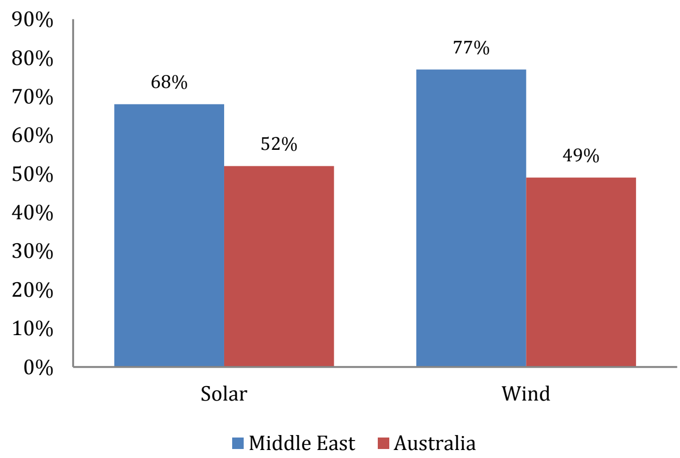


Figure 11 Total average of Solar and Wind energy in Middle East and Australia

The average of wind speed in Middle East countries is depend on the altitude and location, where the total average speed on the 10 meters height is about 6 m/s. while the total average speed on the 100 m is about 9 m/s, so the total average on the 50 m is about 7.7 m/s this value could increase or decrease, that depended on the year time. meanwhile, the average wind speed in Australia also depend on the altitude and location in addition to year seasons, where the total average of wind speed is about 4.9 m/s as shown in table 9.

6. Conclusion

As result of the research above, we can see the availability of Solar and wind energy in Middle East country compared to Australia. therefore, There is a good potential for solar and wind energy which can be used in different applications in Middle East countries, where it can be considered as a place with high potentiality for renewable energy production, also the availability of many open places and near to population density places That will be a catalyst to use renewable energy as a main energy source Instead of fossil energy.

This study is still in its preliminary phase, and further investigations are needed in the following areas: Updating of the model considering transmission costs and other socio-environmental factors. Integration of a storage system into the model and compare the revised performance metrics, and Analyse the impact of renewable energy sources connected to the smart power systems. Identify the annual consumption rate and cost calculation per KW.

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Effect of fuelwood extraction on structure of forest in Farako, Mali.

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Abstract:

People in developing countries need fuelwood to satisfy their energy needs. Out the total energy consumed in Mali, 90 % comes from fuelwood. Fuelwood exploitation poses a serious threat to forests in developing countries. To mitigate degradation dues to fuelwood exploitation, the governments of developing countries are taking steps to create policies to conserve forests and national parks. In Mali the government has created area of protect forests (PF) it is illegal for collectors to exploit fuelwood.

In this study, we assessed the effect of banning fuelwood collection in protected forest areas. We compared the non-protected forest (NPF) and protected forest structures, tree density, the basal area of NPF and PF and calculated the Family Individual Value, Importance Values Indices, and Simpson index. We interviewed villagers to identify the most prefer fuelwood species.

NPF had 2018 individuals (trees and seedlings) per hectare, with 35 species and 17 families. There was no tree with a diameter at breast height (DBH) larger than 60 cm. The basal area in the NPF is 6.79 m^2. PF had 3369 individuals per hectare, with 51 species and 19 families. Its largest tree had a DBH of 165 cm. The basal area in the PF was 16.15 m^2/ha.

We determined that fuelwood exploitation is associated with an increase in tree density, reduction of basal area, and reduction of species diversity. Banning fuelwood exploitation is not sufficient to protect the fuelwood species most preferred by the villagers of Farako.

Introduction

Peoples in developing countries rely on fuelwood to satisfy their energy need (Bhatt B P 2004) (FAO 2007). For example, the energy consumed in Mali, 90% comes from fuelwood; in India, 75 % of energy consumed is from fuelwood; and in Kenya, fuelwood occupies 68 % of total energy consumed (VENKATA RP 1997) (MOE, Kenya's Energy Sector Investment Programme 1995/96- 1999/2000 1995) (SED 2000). People in developing countries collect fuelwood for various purposes such as cooking, selling to make money, and heating in winter. High consumption of fuelwood in developing countries leads to forest degradation. To mitigate the degradation due to fuelwood exploitation, the governments of developing countries are taking steps to create policies to conserve forests and national parks. In Mali the government has created areas of protected forest (PF); where collecting fuelwood and other types of exploitation have been restricted. Forest guards regularly patrol the PF to prevent illegal cutting down of trees.

The village of Farako in Mali, the site of this study, is one example of the application of this policy. The forest in Farako is divided into two parts: protected forest (PF) where fuelwood exploitation is banned and none protected forest (NPF) where people are allowed to collect fuelwood to satisfy their needs.

In this study regard we compared the PF and NPF in Farako. If PF is considered virgin forest, then the difference with NPF will be considered as the effect of fuelwood exploitation in Farako.

Fuelwood exploitation is a major problem in Farako. Fuelwood collectors cut down the trees, collect the woods and take it home to use as fuel for cooking. The people of Farako also use this forest for other purposes such as a source feed for their domestic animals, to collect material to make fences around their houses, and to make roofs and collects plants for medicinal purposes. Previous reports showed that extraction of resources from forests result in different levels of degradation on forest structure, diversity and composition (Kumar R 2005). Degradation of forest may change the forest structure, tree density and open forest canopy structure. The level of degradation due to removal of forest products depends upon the type and amount of products (Shaanker N U 2004). Some research on analyzing the effect of fuelwood extraction has been conducted. Some of the studies aimed to determine what level of fuelwood exploitation leads to degradation of forest to such an extent that it cannot be reversed, while other studies focused on the effect of fuelwood extraction on regeneration and biomass productivity (Nakul Chettri 2002).

The removal of forest products affects forest management and conservation, but unfortunately, forest managers and policy makers working in Farako have not assessed the effect of fuelwood exploitation on forest structure in Farako.

The aim of this study then, was to determine the effect of fuelwood exploitation on forest structure, tree density, basal area and diversity in Farako. The results of this study will allow us to determine; if banning fuelwood collection will prevent degradation of Farako forests. In this study, we do the following:

1) Compared the forest structures, tree density and basal area of NPF and PF.

2) Calculated Family Individual Value; Importance Values Indices, and Simpson index.

Method

Research site

Farako is a small village with a population of nearly 1000 and is located in the region of Sikasso, Mali ($10^{0}50^{'}$ and $6^{0}51^{'}$ S Fig 3); 15 km from the border with Burkina Faso. The forest of Farako covers 15400 ha and is divided between NPF and PF. Compared with villages which are situated in the Sahel area of Mali, Farako has a long dry season from November to May, and a short rainy season from June to October. Average annual rainfall is 1200 mm. The research site was quite hot: from April to May the maximum temperature was 42°C and during December and January the minimum temperature was 25^{0}C. The average temperature in Farako Village is 29.6°C (USAID 2005).

Data collection:

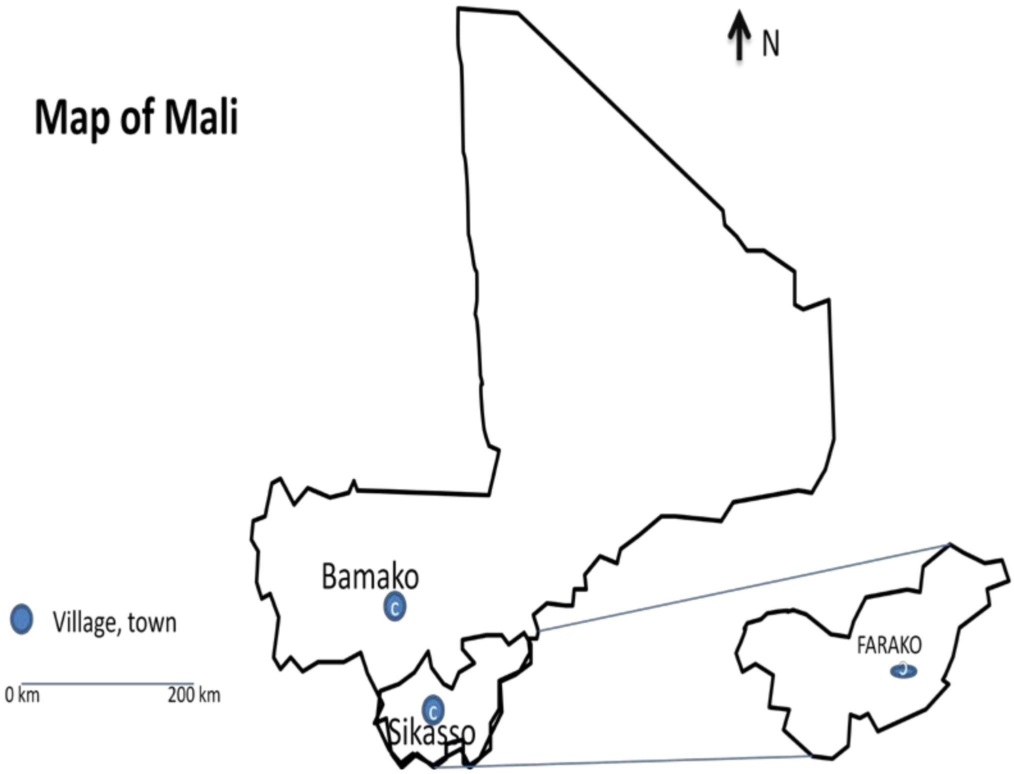
Data was collected in October 2011. Five plots (20 m × 20 m) were randomly set up in each type of forest (protected forest and non-protect forest.). In each plot, DBH greater than 4 cm, and tree with DBH less than 4 cm is consider as seedling, we count those seedlings. Shrubs (characterize by multitude stems and short height) stem were counted. Michel Arbonnier's Guide was used to identify the species of trees and seedlings.

Data analysis

The relative dominance [(RDo), Basal area of a species, divided by area of all plots], relative frequency [(RF) Number of observation of a species, divided by number total of observation] and relative density [(RDe) number of individual of a species, divided by number total of individual in sample] of each species in each type of forest were calculated. The Importance Value Indices (IVI), which is sum of relative dominance, relative frequency and relative density of a species; according to Mori (Mori SA 1983) were also calculated, as well as.

We calculated relative diversity [(RDi): number of species record in one family, divided by number total of species recorder]. We calculate RDo and RDe of each family, then we estimated the Family Individual Values, which is sum of RDi, RDe and RDo for a specie. The Shannon indexes and Simpson's indexes according to Magurran (1988) were calculated to evaluate species.

We interviewed 120 villagers, to know which species they preferred to use as fuelwood.


Map of Mali
N
Bamako
Village, town
0 km
200 km
Sikasso
FARAKO

Results

Forest structure

We identified 5387 individuals (trees and seedlings) in the research plots with 19 families and 56 species.

In the protected forest (PF), tree density was 3369 individuals (trees and seedlings) per hectare. The density of seedling (trees with a DBH less than 4 cm) was 3276 individual per hectare. The density of trees (DBH greater than 4 cm) was 93 individuals per hectare. Of the trees, 46 % had DBH between 10 and 20 cm. The largest tree had a DBH of 165 cm, it is *Prozopis africa*. The basal area of the PF was16.15 m^2/ha.

In the non- protected forest (NPF), tree density was 2018 individuals (trees and seedlings) per hectare. The density of seedlings was 1905 individuals per hectare. The density of trees with a DBH 123 trees per hectare. Those trees has mainly small DBH, 67 % of them have a DBH less than 10 cm. The basal area was 6.79 m^2/ha. The largest tree had a DBH 60 cm, it belongs to *Vittelaria paradoxa.*

In order to characterize the two types of forests, we analyzed forest species composition, and determined important families and species.

Species composition

There was a difference in family and species composition in both types of forests, NPF had 36 species and 17 families while PF had 56 species and 19 families. Relative dominance and relative frequency of species were different in the two types of forest. The same species had different relative dominance and relative frequency in PF and NPF. Family Importance value (FIV), and Individual Value Index (IVI) were also different in NPF and PF (see annex 1 and 2).

The protected forest had 19 families, of which *Cesalpiniaceas* and *Combretaceas* are most diversified with 8 species each. The second most diversified family was *Mimosaceas* with 6 species. Of the 19 families in PF, 10 (53%) had only 1 species each. The most abundant family was *Cesalpiniaceas* which had 1911 individuals (trees and seedlings) and it also had the highest Family Important Value. *Mimosaceas* was a dominant family with a basal area of 9.58 m^2/ha. *Opiliaceas* and *Araliaceas* are two families which had the lowest basal area in PF (close to 0 m^2/ha) and the lowest Family Important Value index. The protected forest had 56 species, of which *Detaruim micratum* had highest Important Value Index and *Gardenia erubescens* had the lowest. The Shannon Wiener index of diversity was 0.92; The Simpson index, which is the probability of randomly taking two individuals of the same species, was 0.26 (see Table1).

The non protected forest had 17 families (The families *Bombacaceas* and *Moraceas* found in PF but absent in NPF). Of the 17 families in NPF, the most diversified was *Mimosaceas* with 7 species, and 11 families (60 %) had only 1 species. Combretaceas was the most abundant family and it also had the highest Family Important Value. Chrysobalanaceas was the most dominant family and *Araliaceous* and *Opiliaceas* had the lowest basal areas. *Detaruim microcarpum* had the highest Importance Value Index, and it was also an abundant specie while *Vittelaria paradoxa* was a dominant species with a basal area of 1.422 m^2/ha (see Table 1 and 2). The Simpson Index Value is 0.11, and Shannon Wiener index of diversity was 1.14 (see Table 1).

Table 1: Specie diversity indices in NPF and PF

Type	SR	S/N	M	ƛ	H’	N1	N2	E
Protected forest	56	0.016	6.77	0.26	0.92	2.51	3.76	0.52
Non protected forest	36	0.017	10.59	0.11	1.14	3.12	8.77	0.73

SR= tree species richness, S= total numbers of species censured; N = number of individuals registered , S/N= rate of species increase per individual recorded, M= Margalef’s index of species richness, ƛ= sum(ni/Ni)^2; H’ = Shannon- Wienner Index, N1= number 1 of hill diversity indices; N2= Number 2 of Hill diversity indices; E= Pielou’s evenness index, E= H’/LnS

The curves of species abundance, show that PF was richer in species than NPF: PF had 55 species while NPF had 35 species. the curves for PF and NPF show a steep gradient, which means they have low evenness. High ranking species have high numbers of individuals while low ranking species have less.

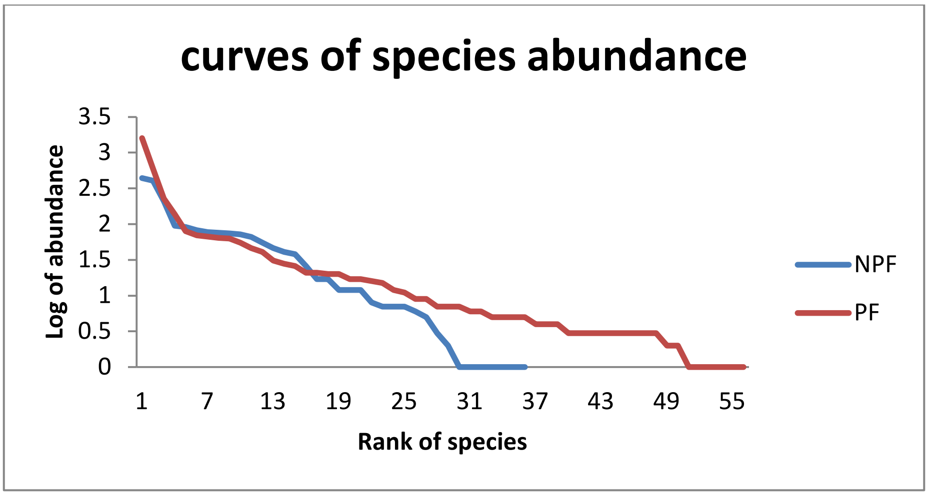


Figure 1: Curves of species abundance

Effect of fuelwood exploitation:

Interviewing the Farako villagers allowed us to identify the 5 most preferred for fuelwood (see Table2). We compared the characteristics of five species in two type of forest to understand impacts of fuelwood exploitation.

Table 2: Five most preferred fuelwood species by villagers of Farako

Species	Rank
Isoberlia doka	1st
Detarium microcarpum	2nd
Pteleopsis suberosa	3rd
Hymenocardia acida	4th
Parinari polyandra	5th
Daniella oliveri	5th

Fuelwood from *Isoberlia doka* is the first preference of the villagers. We found that *Isoberlia doka* was degraded in both the PF and NPF plots with no stems as a symptom. DBH distribution in the remaining 4 species of preferred fuelwood by the villagers shows that, degradation of these species is apparent in both PF and NPF, but more severe degradation was found in NPF over PF. The DBH distribution of *Detaruim microcarpum* and *Pteleopsis suberosa* in NPF show one range of DBH distribution, while in PF there is a wide range of DBH distribution. *Terminalia macroptera* is less degraded in NPF than PF and it has wide range of DBH distribution in NPF, but it has only one range in PF. *Parinari polyandra*'s DBH distribution shows it has small stems in NPF, but has large stems in PF (see fig2)

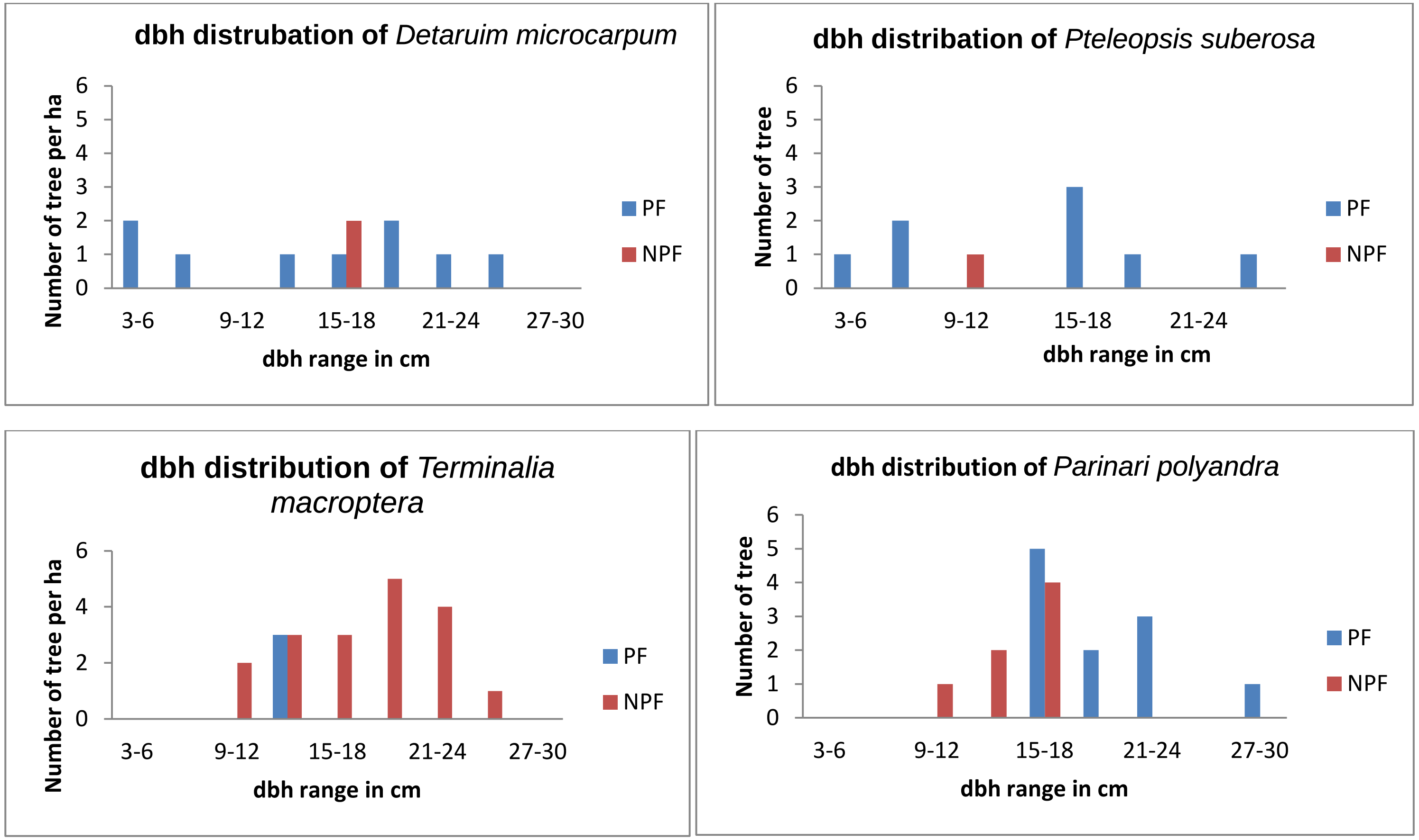
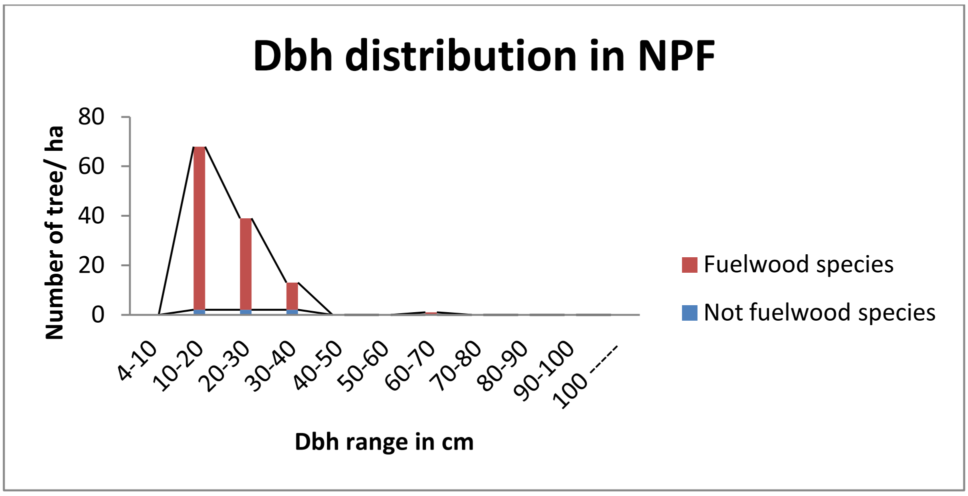
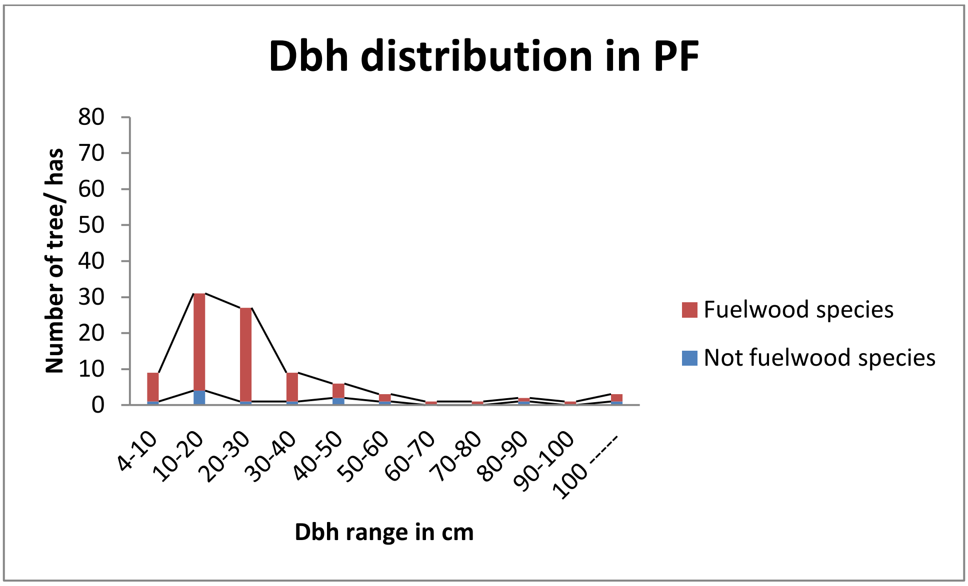


Figure 1: DBH distribution of most preferred fuelwood species in Farako

DBH distribution regardless of species, shows that NPF contained small stems compared with PF. NPF has no stem in which DBH is larger than 60 cm, while PF has some trees which show DBH up to 100 cm. A range of 10-20 cm has highest number of stems in NPF and in PF. A DBH range of 4-10 cm has no tree in NPF, but it has 9 trees in PF. In NPF, 88% of stems have a DBH of 10-30 cm, and in PF, 62% of stems have a DBH 10-30 cm (Fig 3)

Figure 2: DBH distribution in PF and NPF





Discussion:

The results of this study show that NPF's DBH distribution has a class of 4-10 cm without tree, that mean level of survival of seedlings is very low in NPF. It means that the plot has not enough young trees to assure the continuity of forest cover (Robinson A.P. n.d.). The absence of 20 species in NPF compared with PF means that it is losing diversity, We noticed it has no large trees, because people cut them before reach a categories of DBH superior to 60 cm. Both the loss of diversity and the absence of large trees in NPF may be considered as the result of anthropogenic action. The absence of large DBH-class trees may be due to the high pressure of fuelwood extraction, as verified in two other studies (Veblen 1992) (Singh 1998). In case fuelwood exploitation continues in Farako, it may lead to the cutting down of small trees. If that happens, the vegetation in NPF will be totally destroyed, which result in losing any chance of natural regeneration.

DBH distribution in PF shows that it has few trees of DBH class (4-10 cm), that means survival level of seedling is not low as in NPF. The presence of large trees is explained by the restriction of cutting down trees in PF, trees have chance to grow up without been cut down.

The five most preferred species of fuelwood by villagers in Farako are degrading in both NPF and PF. The degradations of the species *Detaruim microcarpum, Pteleopsis suberosa,* and *Parinari i*s more advanced in NPF than PF, while the degradation of *Terminalia macroptera* is more advanced in PF than NPF. Relative abundance of Terminalia macroptera in NPF than PF, maybe due to ecological behaviour of *Terminalia macroptera,* which prefer degrade soil .

One of impact of extraction of forest resources is reduction of diversity (Takuya Furukawa 2011); that is verified by this research too ; NPF has few species compare to than PF. Our sample of PF has 20 species that are absent in sample NPF.

Conclusion:

The results of this study have shown that fuelwood exploitation is associated with a reduction in basal area of a stand, a loss of diversity. DBH distribution shows that NPF has not enough young trees of categories of DBH 4-10 cm, which is serious threat for continuity of NPF, Managers of Farako forest need to intervene to solve this problem, by increase level of survival of seedlings. One noticeable problem is that banning fuelwood collection cannot protect some species from being cut down due to their high quality as fuelwood.

We believe this study is a good tool for forest managers and policy makers in Farako. The results will allow forest managers to fully understand the ecological situation in both protected and non-protected forests and hopefully persuade them to protected forests as a sustainable resource.

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Annexe1: Families with highest values in both NPF and PF

Protected Forest							
Family	NS	NI	BA	RDI	RDE	RDo	FIV
Rubiacees	5	32	0.032	0.098039	0.009584	0.001981	10.96037
Anacardiacees	3	46	0.026	0.058824	0.013777	0.001609	7.420947
Fabacees	4	22	0.45	0.078431	0.006589	0.027854	11.28745
Annonacees	1	59	0.04	0.019608	0.01767	0.002476	3.975374
Loganiacees	1	20	0.19	0.019608	0.00599	0.011761	3.735836
Cesalpiniacees	8	1911	0.86	0.156863	0.572327	0.053233	78.24224
Mimosacees	6	37	9.58	0.117647	0.011081	0.592987	72.17151
Chrysobalanacees	3	95	1.45	0.058824	0.028452	0.089753	17.70279
Combretacees	8	874	0.37	0.156863	0.261755	0.022902	44.15202
Celastracees	1	14	0.0025	0.019608	0.004193	0.000155	2.395546
Bombacacees	1	21	0.27	0.019608	0.006289	0.016713	4.260973
Verbinacees	1	28	0.12	0.019608	0.008386	0.007428	3.54214
Hymenocardiacees	1	54	0.014	0.019608	0.016173	0.000867	3.664693
Sepotacees	1	67	1.17	0.019608	0.020066	0.072421	11.20949
Euphorbiacees	2	49	0.87	0.039216	0.014675	0.053852	10.77424
Opiliacees	1	1	0	0.019608	0.000299	0	1.990733
Moracees	2	2	0.64	0.039216	0.000599	0.039615	7.942966
Araliacees	1	4	0	0.019608	0.001198	0	2.080581
Polgalacees	1	3	0.071	0.019608	0.000898	0.004395	2.49011
Non protected forest							
Rubiacees	2	58	0.23	0.058824	0.0286	0.035931	12.33542
Anacardiacees	2	2	0.067	0.058824	0.000986	0.010467	7.027661
Fabacees	1	12	0	0.029412	0.005917	0	3.532892
Annonacees	1	56	0.322	0.029412	0.027613	0.050304	10.73287
Loganiacees	1	5	0.157	0.029412	0.002465	0.024527	5.640413
Cesalpiniacees	4	754	0.615	0.117647	0.371795	0.096077	58.55186
Mimosacees	7	97	0.828	0.205882	0.04783	0.129352	38.30647
Chrysobalanacees	3	129	1.554	0.088235	0.063609	0.242769	39.4614
Combretacees	5	798	0.894	0.147059	0.393491	0.139663	68.02126
Celastracees	1	0	0	0.029412	0	0	2.941176
Bombacacees	0	0	0	0	0	0	0
Verbinacees	1	1	0.00814	0.029412	0.000493	0.001272	3.117651
Hymenocardiacees	1	7	0.246	0.029412	0.003452	0.038431	7.12941
Sepotacees	1	38	1.422	0.029412	0.018738	0.222148	27.02974
Euphorbiacees	1	17	0.058	0.029412	0.008383	0.009061	4.685529
Opiliacees	1	0	0	0.029412	0	0	2.941176
Moracees	0	0	0	0	0	0	0
Araliacees	1	0	0	0.029412	0	0	2.941176
Polgalacees	1	54	0	0.029412	0.026627	0	5.603898

NS= number of species, NI= number of individuals, BA= basal area, RDI: relative diversity, RDe: Relative density, RDo= Relative dominance, FIV= Family Importance Values

Annexe 2: Comparaison of 20 most important species in NPF and PF

Species	Protected Forest					
	D	BA	RDe	RF	RDo	IVI
Detaruim Microcarpuim	1599	0.082	47.46215	80	0.504038	127.9662
Pteleocarpis siberoza	600	0.063	17.80944	100	0.387249	118.1967
Daneala Doka	58	0.53	1.721579	100	3.25781	104.9794
Prozopis Africana	3	9.263	0.089047	40	56.9379	97.02695
Vitelaria paradoxa	67	1.17	1.988721	80	7.191768	89.18049
Parinari polyandra	28	1.11	0.831107	80	6.82296	87.65407
Terminalia albida	219	0.105	6.500445	80	0.645415	87.14586
Erythrophleum africa	132	0.13	3.918077	80	0.799085	84.71716
Anona senegalensis	57	0.04	1.691897	80	0.245872	81.93777
Strychnos spinosa	20	0.198	0.593648	80	1.217068	81.81072
Bombax costatum	20	0.269	0.593648	60	1.653492	62.24714
Hymenocardia acida	50	0.103	1.48412	60	0.633121	62.11724
Terminalia macroptera	52	0.075	1.543485	60	0.461011	62.0045
Vitex barbata	26	0.114	0.771742	60	0.700736	61.47248
Parinari curatellifolia	5	0.174	0.148412	60	1.069545	61.21796
Cacia siberiana	17	0	0.504601	60	0	60.5046
Swartzia madagascariensis	9	0.0376	0.267142	60	0.23112	60.49826
Gymnosporia senegalensis	14	0.0025	0.415554	60	0.015367	60.43092
Gardenia sokotensis	7	0.015	0.207777	60	0.092202	60.29998
Bridelia ferruginea	8	0.87	0.237459	40	5.347725	45.58518
Non protected Forest						
Species	D	BA	RDe	RF	RDo	IVI
Terminalia macroptera	76	1.2	3.766105	100	17.66488	121.431
Guierra Senegalensis	66	0.0053	3.270565	100	0.07802	103.3486
Isobernia doka	211	0.051	10.4559	80	0.750757	91.20665
Acacia macrostachya	55	0.514	2.725471	80	7.566457	90.29193
Annona senegalensis	74	0.32	3.666997	80	4.710635	88.37763
Terminalia albida	82	0.249	4.063429	80	3.665463	87.72889
Combretum glutinosum	95	0.0694	4.707631	80	1.021619	85.72925
Parinari curitellifolia	46	0.221	2.279485	80	3.253282	85.53277
Gardenia erubescens	12	0.23	0.594648	80	3.385769	83.98042
Hymenocardia acida	7	0.246	0.346878	80	3.6213	83.96818
Detaruim microcarpum	440	0.089	21.80377	60	1.310145	83.11391
Vitellaria paradoxa	38	1.422	1.883053	60	20.93288	82.81593
Strychnos spinosa	5	0.157	0.24777	80	2.311155	82.55893
Bauhinia thonningii	77	0.474	3.815659	60	6.977627	70.79329
Combretum ghasalense	8	0.567	0.396432	60	8.346656	68.74309
Pavetta crassipes	91	0	4.509415	60	0	64.50942
Entada sudanica	17	0.23	0.842418	60	3.385769	64.22819
Parinari polyandra	7	0.131	0.346878	60	1.928416	62.27529
Pteleopsis suberosa	406	0.0031	20.11893	40	0.045634	60.16456
Securidaca longepedunculata	72	0	3.567889	40	0	43.56789

D= density(trees ha^{-1}); BA= basal area (m^2/ha), RDe= relative density, RDo= relative dominance, IVI = Importance Value Index

Topic: Sustainable Development and Education

Environmental Education: A Vital Component of Environmental Awareness Towards Sustainable Development

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Abstract: Environmental education plays the key role in putting into action what Tbilisi, United Nation Conference on Environment and Development, Earth Summit and Agenda 21 had endorsed with regards to environmental education ethics. This is from the standpoint of the individual to the whole international community whatever their age, geographical position, cultural background or intellectual group. According to them a new awareness of the complex and dynamic interrelationship between man and his total environment had to be recognized. One of the primary aims of environmental education as endorsed by the Tbilisi Conference was to enable people to understand the complex nature of environmental issues arising out of biological interaction. The individual and the community had to be provided with the means of interpreting the independence of these various elements in space and time so as to promote a better use of resources. A key concept relates to the view that fostering responsible and effective participation concerning the quality of natural, social, and cultural environment is basic to improvement. To this end, education's role should center on the dissemination of information on development methods likely to maintain and enhance a harmonious relationship with the environment.

Key words: Environment, Environmental Education, Sustainable Development, Agenda 21, Climate Change, Philippines

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Environmental Education: A Vital Component of Environmental Awareness Towards Sustainable Development

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INTRODUCTION

"Climate change is real and is affecting all of us. The world is getting warmer and human activity is a major cause of this. The problem calls for an urgent response; but the situation is not entirely hopeless, at least, not yet. Youth has the highest stake since it concerns our future as well as the present. We need to come together and work as agents of change." - Gopal Kumar Jain, Coordinator, Youth Programmes, CEE –

Every one of us is indeed on a struggle; struggle to survive and to prosper. One of the greatest struggles the human race has ever faced is that which concerns our Planet Earth, the one and only planet where we live, and that struggle is **the fight against climate change**. Most scientists regard anthropogenic *(human-caused*) global climate change to be the most important environmental issue of our time. Evidences gathered by scientists around the world suggest that global climate has been changing as a result of human actions. They found out that in the past century, precipitation has increased by about one percent over the world's continents. High altitudes are expected to see more rainfall while in some tropical areas precipitation has actually declined. Apparently, warmer temperatures are causing more water evaporation. We are expecting this to produce more severe rainstorms, hurricanes, tornadoes, typhoons, and even floods. In 2003 at least 30, 000 people died in Europe's hottest summer since 1540. Climate models given by the scientists show temperature extremes like this will become increasingly common by the end of this century if greenhouse gas emissions are not reduced. Over the past 200 years, atmospheric concentrations of CO_2, CH_4, and N_2O have increased by over 31 percent. Carbon dioxide is the most important cause of anthropogenic climate change. Burning fossil fuels, making cement, clearing forests, and other human activities release nearly 30 billion tons of CO_2 containing 8 billion tons of carbon every year. About 3 billion tons of this excess carbon is taken up by terrestrial ecosystems, and around 2 billion tons are being absorbed by the oceans, thus, leaving an annual atmospheric increase of some 3 billion tons of carbon per year. In Metro Manila alone, excessive carbon emissions are virtually evident. In the daytime, try to stand on the 5^{th} floor of a building; look at the air outside the windows, and you will notice how dusty the air you breathe is. In the nighttime, try to look at the velvety sky, and the stars you see are limited to the brightness. You cannot anymore see those that appear smaller unlike when you are in the rural areas where the atmospheric conditions are better. If the current trends continue, climatologists warn that by year 2100, the mean global temperatures will probably be between 1.5^0C and 60^0C (2.7^0F and 11^0 F).

The global climate change has been already affecting a wide variety of biological species. Many wild plant and animal species are being forced out of their current ranges as the climate warms. Likewise, coral reefs are bleaching because of higher water temperatures. British scientists warned that by 2050, even the lowest estimates of potential climate change could drive one million species into extinction. If migration to a more suitable habitat is blocked through fragmentation, more than half of all tropical species might be eliminated.

Satellite images show that the Arctic sea ice is 40 percent thinner now, and the Antarctic ice sheet, including some of the giant icebergs has shrunk 25 percent over the past 25 years. Alpine glaciers everywhere are retreating rapidly. Over the next 50 years, at least half of all alpine glaciers in the world can disappear. Without these glaciers, agriculture, industry, power generation, and drinking water supplies will suffer. In the past century, the sea level has risen approximately 15-20 cm (6-8 in) worldwide. About one-quarter of this increase is caused by the melting of alpine glaciers and one-half is due to thermal expansion of ocean water.

Can we do something to alleviate this problem considering our being too small? But no matter how tiny as a dot we are, we can scribe a difference, we can touch the world. WE CAN MAKE A DIFFERENCE.

RECOGNIZING THE ENVIRONMENTAL ISSUE AND SUSTAINABLE DEVERLOPMENT

Environmental consciousness can be viewed as a child of the sixties in terms of its widespread recognition. Renowned scholars such as R. Carson (1962), B. Commoner (1971), and P. R. Ehrliick (1969) warned of the detrimental effect of exponential population growth and rapid technological development on our environment. These and others warned that our very survival rested in achieving a sensitive balance between the considerable and mounting forces affecting the environment.

The alarm sounded was based on dangerous levels of pollution in water, air, earth, and living things and major disturbances to the ecological balance, depletion of irreplaceable resources, and tragic neglect of the man-made environment. It had to take a series of disasters before everyone started realizing the need to take care of and nurture the environment. Indeed--- the Chernobyl accident, Mt. Pinatubo eruption, smaze in Indonesia and Australia, Ormoc and Ondoy floods--- if they didn't happen, people would probably still be abusing the environment.

It is therefore not surprising that people have gained a renewed perspective toward the use of resources taken from the environment. A prerequisite to more sensitive attitudes, of course, is increased understanding. And thanks to media attention, world leaders are taking steps to ensure the continued productivity of our natural resources.

In the Tbilisi Conference sponsored by the United Nations, attendees recognized the need to concentrate on the education component of environmental awareness. It constituted the starting point of a new phase of interest where environmental education (EE) was seen as the centerpiece of all efforts that aim to effect change in the attitude and behavior of people toward the environment. It saw education as a lifelong process that needed to be provided at all levels, both in and out of school.

In June of 1992, the United Nations Conference on Environment and Development (UNCED) convened in Rio de Janeiro, Brazil. This international body endorsed an additional component in the environmental education master plan which is the sustainable development. *Sustainable development* is defined as a kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs. To achieve sustainable development, citizens must develop decision-making strategies that would make sure that the health needs, economic security, and environmental quality are maintained simultaneously (Manitoba Education and Training, 1993). Recommended strategies and approaches for achieving sustainable development are outlined in Agenda 21: *An Action Plan for the 21st Century* developed through United Nations Conference on Environment and Development (UNCED). This document recognizes education as the key for providing individuals with the awareness, attitudes, values, and skills needed to undertake responsible decision making regarding human development. *Agenda 21* also promotes the integration of environmental and developmental education in all disciples.

Sustainable development is generally accepted as having three intervening components such as environment, society, and economy. An example of which is shown by the existence of a healthy, prosperous society with a healthy environment providing food and resources, safe drinking water, and clean air for its citizens. The sustainability paradigm do not accept the fact that casualties in the environmental and social realms are inevitable and acceptable consequences of economic development. The UNESCO .Education for Sustainable Development Toolkit has a different view of sustainability. According to them sustainability is a paradigm for thinking about a future with balanced environmental, societal and economic considerations in the pursuit of development and improved quality of life.

18 PRINCIPLES OF SUSTAINABILITY

The Rio Declaration on Environment and Development provided a listing of 18 principles of sustainability.

1. People are entitled to a healthy and productive life in harmony with nature.
2. Development today must not undermine the development and environment needs of present and future generations.
3. Nations have the sovereign right to exploit their own resources, but without causing environmental damage beyond their borders.
4. Nations shall develop international laws to provide compensation for damage that activities under their control cause to areas beyond their borders.
5. Nations shall use the precautionary approach to protect the environment. Where

there are threats of serious or irreversible damage, scientific uncertainty shall not be used to postpone cost-effective measures to prevent environmental degradation.

6. In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process, and cannot be considered in isolation from it. Eradicating poverty and reducing disparities in living standards in different parts of the world are essential to achieve sustainable development and meet the needs of the majority of people.
7. Nations shall cooperate to conserve, protect and restore the health and integrity of the Earth's ecosystem. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.
8. Nations should reduce and eliminate unsustainable patterns of production and consumption, and promote appropriate demographic policies.
9. Environmental issues are best handled with the participation of all concerned citizens.
10. Nations shall facilitate and encourage public awareness and participation by making environmental information widely available.
11. Nations shall enact effective environmental laws, and develop national law regarding liability for the victims of pollution and other environmental damage. Where they have authority, nations shall assess the environmental impact of proposed activities that are likely to have a significant adverse impact.
12. Nations should cooperate to promote an open international economic system that will lead to economic growth and sustainable development in all countries. Environmental policies should not be used as an unjustifiable means of restricting international trade.
13. The polluter should, in principle, bear the cost of pollution.
14. Nations shall warn one another of natural disasters or activities that m a y have harmful transboundary impacts.
15. Sustainable development requires better scientific understanding of the problems. Nations should share knowledge and innovative technologies to achieve the goal of sustainability.
16. The full participation of w o m e n is essential to achieve sustainable development. The creativity, ideals and courage of youth and the knowledge of indigenous people are needed too. Nations should recognize and support the identity, culture and interests of indigenous people.
17. Warfare is inherently destructive of sustainable development, and Nations shall respect international laws protecting the environment in times of armed conflict, and shall cooperate in their further establishment.
18. Peace, development and environmental protection are interdependent and indivisible.

The "Rio principles" provide us the parameters to envision locally relevant and culturally appropriate sustainable development for our own respective nations, regions, and communities. These principles help us to have a clearer understanding of the abstract concept of sustainable development and to work on its implementation

YOUTH AND SUSTAINABLE DEVELOPMENT

Youth have always been regarded with both special concerns and special responsibilities in relation to the environment. Undoubtedly, they would be greatly affected by a number of environment risks and hazards we all inherited from our ancestors. They are expected to engage in new form of environmental action and activism that will hopefully generate more effective responses to environmental challenges.

There are three forces that adversely affect our global environment. These are the political and economic problems made worse by rapid population growth. These problems are caused by humans who are called upon to put back the global environment in its former good shape. Experts continuously think of ways to improve the state of environment but information on what we can do does not get to most of us. We get regular reports on the weather and stock markets but we rarely hear news of world grain yields of species extinction.

We cannot face the future unless we take care of the present. We see our deserts expanding. The forests are diminishing, and the agricultural lands are becoming less fertile and stripped of its trace minerals, while the population of the world is increasing. If we do not change our way, nature will check us in its own way. We have to do our share in our planet. The power of the mind and the will to change things can prevent big disasters. Big disaster can be avoided if people work together with positive thoughts and love. Who say we cannot save Mother Earth? If we have the political will and the discipline, nothing is impossible!

I know that most young people are aware of the numerous environmental problems facing their communities and some have already taken appropriate actions. Often however, young people are unable to address environmental issues because of their lack of information regarding them. Though we are waking up to the need to change our attitudes and practices concerning the environment, our efforts are not exerted fast enough to avert the dire consequences of our negligence. We as educators should then work hard together so as to motivate our youth to save our environment not only for themselves but also for the future generations.

ENVIRONMENTAL EDUCATION

A new ethic was being sought through environmental education. From the individual to the whole international community--- whatever their age, geographical position, cultural background or intellectual group--- a new awareness of the complex and dynamic interrelationship between man and his total environment had to be recognized. One of the primary aims of environmental education as endorsed by the Tbilisi Conference was to enable people to understand the complex nature of environmental issues arising out of biological interaction. The individual and the community had to be provided with the means of interpreting the independence of these various elements in space and time so as to promote a better use of resources. A key concept relates to the view that fostering responsible and effective participation concerning the quality of natural, social, and cultural environment is basic to improvement. To this end, education's role should center on the dissemination of information on development methods likely to maintain and enhance a harmonious relationship with the environment. In short, EE has to contribute to the advancement of knowledge and the acquisition of attitudes and skills required for the preservation and improvement of the quality of environment.

The health of the environment is essential to the health and well being of every person and not a mere incidental concern. When the environment is compromised, so are we. Our environment, once a subject of concern only to ecologists and environmental activist, now concerns all. The government has initiated the move to environmental protection through law, ordinance, programs and projects. Media disseminates basic information; non-government organizations have joined hands in pursuing the cause of the environmental protection.

For a long time the solution to environmental problems was perceived to be the replenishment of the resources that were being depleted, for example, deforested areas required reforestation programs. There is now-growing recognition that long-term solutions to environmental problems need to be directed towards changing behavior. The complexity of some environmental problems and the inability of people to solve them also challenge the traditional view. Problems such as the depletion of the ozone layer and the greenhouse effect, caused by excessive carbon emissions, cannot be resolved using the traditional approach.

There is also greater acknowledgement of the need to change our consumption habits. The world's resources cannot meet the demands of the world population where consumption levels are on the rise and developing countries follow the pattern set by people in the developed countries. And even if this were possible it would still be impossible to provide for future generations with similar demands.

In view of sustained assaults on the environment and the potential threat thus posed to mankind, environmental education could be given more consideration. The environment is being attacked from land, sea and air. The hue and cry raised by environmental issues is indicative of the genius feeling of the collective fear and concern. The environment is central to the survival of mankind. This fact is in the biblical history of creation, where *God* created the environment and put Man in it to ensure his comport and to guarantee his survival. Mankind in his bid to make life more comfortable has become environmentally thoughtless. Technological innovations have little respect for environmental protection, the motivating factor being essentially profitability and performance.

The world wide environmental crisis affects every member of our species. No single individual, group or nation, regardless of our economic status or privileged political position can escape the global consequences of these overarching new environmental realities. Their impacts will continue to be felt by every human being and by every other species with which we share this planet.

As we welcome the new millennium there is no doubt that our lives would be more relevant if we will be able to live in harmony with the massive changes taking place around us and fully reflect on today's new realities.

According to United Nations Environment Program (UNEP), youth comprise nearly 30 percent of the world's population. The involvement of today's youth in environment and development decision-making and in the implementation of programs is critical to the long-term success of Agenda 21. As stipulated in its basis for action, it is imperative that youth from all parts of the world participate actively in all relevant levels of decision-making processes because it affects their lives today and has implications for their futures. In addition to their intellectual contribution and their ability to mobilize support, they bring unique perspectives that need to be taken into account.

Education utilizes the findings of science and technology in creating awareness and a better understanding of environmental problems. It must foster positive values of conduct towards the environment and the correct use of natural resources. A careful attention to environmental issues is deemed to be important in improving the quality of life. The man has the duty to be aware of our environment for sustainability and protection (Yaghoobi, 2003). The youth are considered as one ne of the most important people for saving and protection of nature. Student's environmental awareness is one of the most important indicators for displaying national civilization. It reflects many aspects of environmental status such as personal consideration and behavior, public capacity and the local citizens' attitude towards sustainable society as a whole, etc. (Kaiser, 2003).

Athman and Monroe (2000) stated that environmental awareness of processes and systems play an important role in Environmental Education. Regarding awareness, Palmer (1998) emphasized that students should acquire appropriate range of awareness, understanding and concepts about the environment so that critical judgment can be achieved. On the other hand, Madsen (1996) explained that environmental awareness is necessary to achieve environmental protection and restoration. Madsen emphasized that the students must have a basic grasp of environmental problems. Awareness was studied along with environmental knowledge and concern by Hausbeck *et al*. (1992).

They concluded in their study that awareness and concern scores were significantly higher than knowledge levels in high school students. They linked this result with the fact that a primary source of environmental information is electronic media. Also attitude is one of the important components in EE which is investigated in this study. Following Cluck *et al*. (1997), environmental attitudes have been conceptualized as a 3 dimensional concept. The dimensions of environmental attitudes include environmental worldview, environmental concern and environmental commitment. There are many theoretical and empirical approaches to investigate environmental attitudes (Dunlap and Van, 1978; Buttel, 1978; Ramsey and Rickson, 1976) though conceptualization and operationalization of environmental attitudes varies in and across studies, most approaches identify environmental attitudes as a component of environmentalism.

Environmental values, the relationship between the environment and society and perceptions of natural source consumption directly affect overall environmental balance (Dunlap and Van, 1978). The effects of individual factors on environmental attitudes have been examined by researcher.

There are some predictors of environmental awareness and attitude, like gender, residence, income and political tendency which are investigated by Arcury (1990), Tarrant and Cordell (1997) and Dunlap and Van (1978). In a study of cohort group differences in environmental concern, Honnold found decreased levels of environmental concern in almost all age groups since the 1970s.

How can we motivate students to take concrete steps toward promoting sustainable action to stop climate change? Even if there is a commitment to provide environmental education in general and *biology* in particular as a saving grace, the question remains: How should climate change concepts be taught to students? Biological sciences offer excellent opportunities to teach ecological concepts. Similarly, environmental issues with direct biological implications can be logically dealt with, like global warming, climate change, endangered species, population control, and the like. Environmental Education (EE) is seen to be the development of understanding about our environment, positive attitudes toward the earth and its life, and confidence and skills to make positive changes. However, a key determinant of student achievement is the quality of teaching. **To be effective, the infusion of environmental education concepts in any subjects, so to speak, requires strategies and learning experiences that are planned, focused, experiential, participatory, anticipatory, and cumulative**. All students must have access to learning about the environment. The knowledge-and-concept base must include the students' ability to demonstrate an understanding of the ecological processes that support life on our planet, man's interaction with the ecological processes, and an understanding of the effects and the likely implications of change. Likewise, the students should be taught how to recognize the causes and effects of environmental issues, make responsible decisions about the environment, and take personal as well as collective action to ensure an ecologically sustainable future.

Recognizing the need to address climate change, and anticipating its effects on people's lives, we as educators need to make substantial contributions to the alleviation of environmental problems by making the students environmentally literate and responsible as regards the causes and effects of global warming and climate change.

The government recognizes the role of education in affecting change. Based on underlying philosophy that education is behavior modification. It follows that educators are agents of change. The importance of education cannot be underestimated when we talk about problems encountered by all of us not only in terms of social and economic concerns but also on the recent environmental challenges we are into now. Thus education is now viewed as an essential catalyst in solving these problems with considerations on sustainability. For this reason, government thrusts find their way into the educational systems, into the curriculum through the teachers.

Environmental education has to rekindle its primary objective: to provide different groups of people in various sectors and the youth in particular with the knowledge *needed to develop a sense of responsibility towards the environment and the rational utilization of its riches. This education should inculcate competencies needed for the solution of environmental problems and foster the highest cultural level of human's productive activity.*

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She has written several articles in prestigious journals and magazines on teaching, health and environment and textbooks and laboratory manuals in Botany, Zoology, Chemistry, Nuclear Physics, Anatomy and Physiology, Physical Science, Biological Science and Ecology. She has also been invited as resource speaker and lecturer on health and environmental issues, and science education in national and international trainings and conferences. She is now into writing news in allvoices, notes in facebook and blogs in Blogspot.

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In-Situ Remediation of Groundwater by Nano Zero-Valent Iron (nZVI) Particles Extracted from Steel Industry Waste

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ABSTRACT

Since the late 1990s, the use of nano zero valent iron (nZVI) for groundwater remediation has been investigated for its potential to reduce subsurface contaminants such as PCBs, chlorinated solvents, and heavy metals. nZVI shows tremendous promise in the environmental sector due to its high reactivity and as such, numerous laboratory and field studies have been performed to assess its effectiveness. In this study sludge sample of the Basic Oxygen Furnace (BOF) of SAIL, Durgapur, India, was used to convert it into nano particles of iron. The iron oxide (FeO/Fe_2O_3) content of BOF slag can be as high as 38%, which represents the amount of oxidized iron that cannot be recovered during the conversion of molten iron into steel. This iron was reduced using sodium borohydride for converting it into nano Zero Valent Iron (nZVI). The particles formed were stabilized using Poly Acrylic Acid (PAA) and Tween-20, a biodegradable surfactant, for enhancing its mobility in groundwater. This study reveals the utility of steel industry waste for in-situ remediation of contaminated groundwater.

Keywords-Zero Valent Iron (ZVI), Heptachlor, in-situ, Groundwater

1. INTRODUCTION

Remediating groundwater contaminated with chlorinated hydrocarbons has been one of the most challenging tasks for almost three decades. A more effective treatment has been in search due to the shortcomings associated with the traditional methods like “Pump and Treat” requiring decades of time and operation cost, ”Thermal Treatment” like steam injection requires high cost and may cause contaminant re-mobilization, ”Permeable Reactive Barriers”, ”Bioremediation” results in slow biodegradation rates or “Excavation followed by landfill ” is a highly environmentally disruptive and prohibited in industrial and residential areas (Zhao and He, 2011). As just one aspect of the global nano-revolution, the potential use of engineered nano-materials for the treatment of polluted waters has sparked a great deal of interest. Compared to conventional macroscale materials, nano-materials exhibit significant improvements in surface area as a function of mass. By using a smaller mass of material, to achieve the same objective, both raw materials and energy can be theoretically conserved (Masciangioli and Zhang, 2003) with significant associated cost savings. Conceptually, the key properties required for the use of any engineered nanoparticle, for in situ remediation of polluted groundwater, are: (i) high reactivity for contaminant removal; (ii) sufficient mobility within porous media; (iii) sufficient reactive longevity; and (iv) low toxicity. Halogenated hydrocarbons like chlorinated methane, chlorinated benzene etc can be reduced to benign hydrocarbons by nanoiron particles (Zhang, 2003). Iron nano-particles have also been used for the removal and stabilization of metals or metalloid contaminants in soil and water media. Reduction of arsenic mobility in groundwater (Kanel et al., 2005, 2006), removal of Cr(VI) from wastewater has been examined (Hu et al., 2004).

The utilization of waste material rich in iron content can be used as a starting material for nanoiron particle production. The sludge produced in the steel industry, from the Basic Oxygen Furnace (BOF), is the main focus of this study. The total steel production in India is about 25 million tones and the waste generated annually is around 8 million tonnes (considerably higher than the world average) (Technology Information, Forecasting and Asessment Council (TIFAC, 2005). The BOF sludge produced from the steel industry is an ecological hazard and is normally dumped in the landfill site. Since it has high percentage of iron, it was chosen as the starting material for producing nano-iron particles. This can serve dual purpose of utilizing the waste as well as producing some reactive particles, which could be utilized for environmental remediation and contribute to zero waste programme.

This paper deals with the production of nano particles from steel waste and its utilization in remediation of halogenated pesticide, heptachlor. The nano iron particles were modified by using surfactant like Poly Acrylic Acid (PAA) and Tween 20 so that the agglomeration of iron particles may be reduced. The effect of surface modification on reduction of heptachlor was also studied.

2. MATERIALS AND METHODS

Sludge sample of the Basic Oxygen Furnace (BOF) of SAIL, Durgapur was used in the study. Digestion of the sludge sample was done using the standard digestion procedure of EPA method (3050B). The chemical method of synthesis of nano zero valent iron (nZVI) was carried out in a 500 ml three necked flask. Nitrogen gas was purged to achieve an anaerobic atmosphere during the synthesis. Addition of sodium borohydride, the reductant, was added dropwise, at 2mL/min, to the digested sludge sample. The mixture was stirred during the entire process. 10 mL of the acid digested sludge sample was taken and 3.5 g of sodium borohydride/10mL of deionized water was slowly added forming nano iron particles. The nZVI formed was extracted in ethanol and was stored in a vacuum dessicator to prevent its oxidation. The Gas Chromatograph (Thermo Scientific, Chemito, Ceres 800 Plus) was used for measurement of pesticide, heptachlor. The Samples were extracted with n-hexane and analyzed using GC equipped with Electron Capture Detector (ECD). Agilent (30 m X 0.25 mm ID) capillary column was used for separation of heptachlor. The carrier gas was chromatographic grade nitrogen. Sample injection volume was 1µL, in splitless mode, with the injector temperature set at 275°C and the detector set at 325°C. Separation was conducted with a temperature program that started oven temperature at 160°C and then ramped at 7°C/min to 300°C. Batch experiments were conducted to investigate the reaction kinetics of the nanoiron particles with pesticide heptachlor. The dechlorination of heptachlor was conducted in 20 mL vials mixed with a definite dose of nanoiron particles. The filling of the pesticide was done using a separating funnel being purged with nitrogen gas for sometime and leaving no head-space in each vials. The initial and final weights were taken to find the exact amount of nanoiron particles to be added. The reaction vials were sealed with Teflon rubber septa and incubated at 25°C while stirring on a rotary shaker at 50 rpm. Controls without nanoscale iron were prepared following the same procedure. Duplicates vials were kept for each time series. After the specified time, the vials were sacrificed for determination of pesticide concentration remaining in each vial. The oxidation reduction potential (ORP) and pH in the vials were monitored by a pH and ORP meter (Digital pH meter,Cyber Scan and Oaklan-Eutech Instruments,ORP Tester 10,10 BNC) as soon as the vials were taken out from the rotator. The total run time of the batch study was 48 hours with samples being withdrawn at an interval of 30 minutes, 1hour, 2 hours, 5 hours,8 hours, 12 hours, 18 hours, 24 hours and

48 hours respectively. Preliminary studies were conducted to optimize the dose of the nanoiron. Four doses of nZVI (5g/L, 10g/L, 25g/L and 50g/L) was taken and the dose with the maximum degradation efficiency was chosen for further kinetic studies. Surfactant modified nZVI, by using Poly Acrylic Acid (%) and Tween 20 (%) was also used to run the batch study to study the impact of surface modification on reduction of pesticide. The samples were extracted with n-hexane using the best extraction ratio and the combined organic extracts were analyzed using GC equipped with Electron Capture Detector (ECD). The particle size was analysed by using Malvern Particle Size Analyser at the department of Chemical Engineering, ISM, Dhanbad. The BET surface area analysis was done at NML, Jamshedpur.

3. RESULTS AND DISCUSSION

3.1 Characterization of S-nZVI

The nano particles formed showed high agglomeration. The average particle size for bare S-nZVI was found to be 1660 nm. When the particles were stabilized by using surfactant like PAA the average particle size reduced to 303 nm. Similarly the BET-Surface area analysis result revealed a specific surface area of 0.3647 m^2/gm. The reason for getting low values of surface area may be attributed to agglomeration of nano particles and higher values of size.

3.2 Dechlorination of Heptachlor by S-nZVI

Preliminary batch experiments were performed to estimate the % reduction of Heptachlor by S-nZVI. Four doses of nZVI at 5g/L, 10 g/L, 25 g/L and 50 g/L was chosen for degrading Heptachlor. The degradation efficiency increased with the dose and highest efficiency was achieved at 50 g/L. Hence, this was chosen as the optimum dose for degradation of Heptachlor. Batch experiments were carried out in 20 mL borosilicate glass vials equipped with septa and screw caps. Ten vials containing 1 mg/L heptachlor, and 50 g/L S-nZVI were kept in a rotator at 50 rpm, such that the axis of vials remain horizontal, and the vials were taken out at specified time intervals viz., 0.5, 1, 2, 5, 8, 12 18, 24 and 48 hrs. The pH and ORP was measured as soon as the vials were taken out of the rotator. Aqueous concentration of heptachlor was measured by taking 0.25 mL of aqueous solution and adding it to 0.88 mL of hexane. The extraction was carried out on vortex mixer for a time period of 15 min. The aqueous concentration was determined by analyzing the hexane by GC.

Analysis by GC showed that concentration of heptachlor decreases with reaction time. The concentration declined to 65 µg/L in 48 hrs (Figure 1).The initial pH of heptachlor solution was 6.57 which rose to 9.46 within 30 min and after which it remained constant. The reduction rate of Heptachlor normally becomes slow after about 24 h. It may be caused by the productionof passivating oxide surfaces on S-nZVI which prevents further corrosion of particles and reduction in rates. The initial ORP value of around 154 mV decreased instantly to -428 mV after adding nanoscale Fe particles.

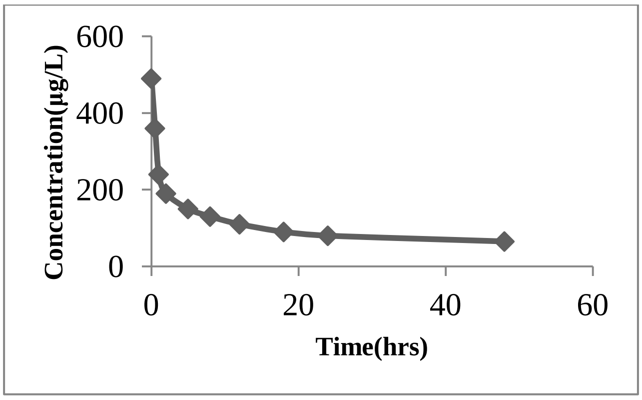

Figure 1: Decline in Heptachlor Concentration with time

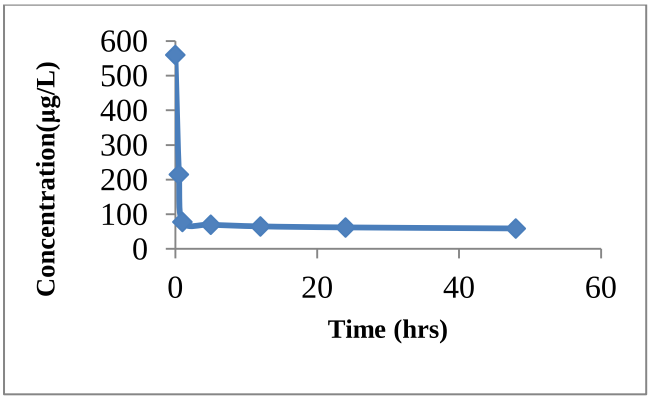

Figure 2: Decline in Heptachlor Concentration with time using PAA/S-nZVI

4.3 Dechlorination of Heptachlor by Surface Modified S-nZVI

Five vials containing 1 mg/L heptachlor along with 5% PAA as surfactant and 50 g/L S-nZVI were kept in a rotator at 50 rpm, such that the axis of vials remain horizontal, and the vials were taken out at specified time intervals viz., 1, 5,12, 24 and 48 hrs. The batch experiments showed that concentration of heptachlor decreases with reaction time. The concentration declined to 59 µg/L in 48 hrs (Figure 2). The initial pH of heptachlor solution was 6.57 which rose to 9.25 within 30 min and after which it remained constant. The initial ORP value of around 13 mV decreased instantly to -393 mV after adding nanoscale Fe particles.

Five vials containing 1 mg/L heptachlor along with 5% Tween 20 as surfactant and 50 g/L S-nZVI were kept in a rotator at 50 rpm, such that the axis of vials remain horizontal, and the vials were taken out at specified time intervals viz., 1, 5,12, 24 and 48 hrs. Analysis by GC showed that the concentration declined to 138.88 µg/L in 48 hrs (Figure 3).The initial pH of heptachlor solution was 6.57which rose to 9.61 within 30 min and after which it remained constant.The initial ORP value of around 13 mV decreased instantly to -428 mV after adding nanoscale Fe particles. Experiments conducted by using pure n-ZVI particles showed that the concentration of heptachlor declined to 38.91 µg/L in 48 hrs (Figure 4).

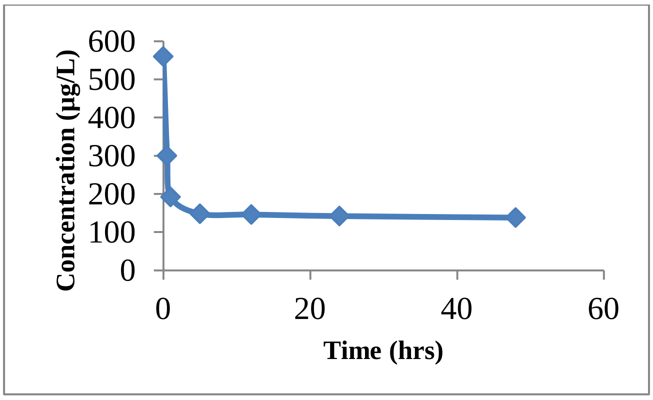

Figure 3: Decline in Heptachlor Concentration with time using Tween 20 modified S-nZVI

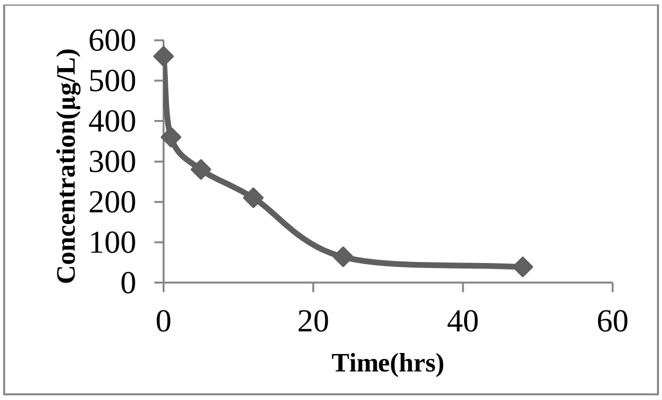

Figure 4: Decline in Heptachlor Concentration with time using pure nZVI

4. CONCLUSIONS

Batch experiments demonstrated that the sludge nanoscale iron particles could effectively dechlorinate Heptachlor. The Reduction efficiency for bare S-nZVI, PAA Modified, Tween 20 modified S-nZVI and pure n-ZVI was 87%, 89%, 75 % and 93% respectively. Hence it was concluded that the nano particles generated from the steel waste can be used as an effective measure to dehalogenate the pesticide heptachlor present in groundwater. The efficiency of reduction by S-nZVI can be enhanced by modifying the particles by surfactant like Poly Acrylic Acid (PAA) which also enhances its mobility and stability.

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NIGERIA, CLIMATE CHANGE AND RENEWABLE ENERGY ALTERNATIVES: TODAY'S REALITY AND FUTURE PROSPECTS

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Abstract

This paper examines Nigeria's energy source s and climate change. It links climate change to emission of greenhouse gases (GHGs) resulting from the combustion of fossil fuels. It also identifies several renewable energy sources available in the country just as a shift from fossil fuels to renewable energy-dominated energy market, is anticipated globally. It recommends increased funding and encouragement of further research studies aimed at harnessing the country's several renewable energy sources. It also advocates increased awareness campaign on the adverse role of deforestation in climate change and global warming.

Key words: Fossil fuels, climate change, greenhouse gases, Global warming, Renewable energy, environmental pollutions.

Introduction

With the advent of industrial revolution in Europe in the 18th century, machines were invented not only to relief man of the strenous labour of production but also to increase production to meet the needs of the rapidly growing population. As such, fossil fuels became very useful as they helped in powering the machines. But centuries later, these fossil fuels (petroleum, natural gas, coal etc) which were warmly embraced have turned out to pose one of the greatest threats to mankind and his planet, earth-fossil fuels have been implicatedd for climate change. It is widely believed that the combustion of fossil fuels results in the emission of carbon and other greenhouse gases (GHGs) which deplete the atmosphere's ozone layer and the consequent climate change and global warming (Ominigbo, 2010a; Akpofure, 2009).

As part of adaptation and mitigation measures against climate change, there is a growing campaign for a paradign shift from traditional fossil fuels to embrace new, cleaner and greener technologies and energy sources (Ominigbo, 2010a; Plummer *et al*, 2010; Montgomery, 2003). This explains why governments, locally and internationally, are being urged to prioritise "greener economy" in their policy making processes with the aim of protecting the intigrity of our planet. This paper therefore, examines some of the renewable energy alternatives available in Nigeria in the face of the manifestation of climate change**.**

Conceptual Framework

The shift from fossil fuels to renewable energy alternatives is not merely because fossil fuels are no longer workable and affordable. Rather, in this era where resources exploitation emphasizes development, fossil fuels are thought to be less sustainable. There are better, cheaper and safer energy alternatives (Ominigbo, 2010b; Curtis, 2011).

Presently, there is a debate raging on the status and sustainability of petroleum. While the petroleum geologists caution that the world's petroleum reserves may soon be exhausted baring new discoveries of new reserves, the economists opine that the current reserves if properly managed, could serve beyond this generation just as they argue that new petroleum deposits would always be discovered. Today, the world's recoverable oil reserves are approximately around 1,000 billion barrels. And presently, about 85 million barrels of oil is consumed daily. Baring new discoveries of reserves, this implies that current reserves could only serve some thirty to forty more years (Plummer et al, 2010). Whereas this paper is not aimed at ascertaining which position (between the geologists and economists) is correct, it is however intended to examine what renewable energy options are available for Nigeria in the face of the anticipated shift from fossil fuels to renewable alternatives, locally and globally.

Nigeria and the Energy Crisis

Despite the concern raised over their environmental safety and or implications, fossil fuels still remain the dominant driving force of world energy market today. While the industrial revolution was driven by coal in Europe, the coal age gave for petroleum interval about a century ago (Plummer et al, 2010). With estimated 180 trillion cubic feet of natural gas and 36.2 billion barrels of crude oil reserves, Nigeria ranks among the world's 10 largest producers and exporters of crude oil and natural gas Akpofure, 2009; Ominigbo, 2010a). The exploitation petroleum and natural gas has however, resulted in several environmental pollutions (Aigbedion & Iyayi, 2007), Table 1. Also, petroleum and coal are believed to have contributed 46.6% million metric tons of the 23.5 million metric tons of carbon emitted in Nigeria by 2001 (Usman & Tijani, 2007).

Table 1:Air Pollution due to Gas Flaring

Year	Volume of gas flared (cubic metres, m^3)	Particulate ashes emissions (tones)	Oxides of sulphur SO_X (tones)	Carbon monoxide emissions (tones)	Oxides of Nitrogen NO_X emission (tones)	Growth rate of NO_X (0/0)
1970	7,957,000,000	1263.8	74.9	2527.5	12,638	Na
1971	12,790,000,000	2031.4	120.4	4062.7	20,314	+60.7
1972	16,848,000,000	2675.9	158.7	5351.7	26,759	+31.7
1973	21,487,000,000	3412.6	202.2	6825.3	34,126	+27.5
1974	26,776,000,000	4252.7	252.0	8505.3	42,527	+24.6
1975	18,333,000,000	2911.7	172.5	5823.4	29,117	-31.5
1976	20,617,000,000	3274.5	194.0	6549.0	32,745	+12.5
1977	20,673,000,000	3327.7	197.2	6655.3	33,277	+1.6
1978	19,440,000,000	3087.5	183.0	6175.1	30,875	-7.2
1979	26, 673,000,000	4141.0	245.4	8282.0	41,410	+34.1
1980	22,904,000,000	3637.7	215.6	7275.4	36,377	-12.2
1981	14,162,000,000	2249.3	133.3	4498.5	22,493	-38.2
1982	11,940,000,000	1896.4	112.4	3792.7	18,964	-15.7
1983	11,948,000,000	1897.6	112.5	3795.2	18,976	-0.1
1984	12,817,000,000	2035.6	120.6	4071.3	20,356.4	+7.3
1985	14,846,000,000	2357.9	139.7	4715.8	23,578.9	+15.8
1986	13,917,000,000	2210.3	131.0	4420.7	22,103.5	-6.3
1987	12,291,000,000	1952.1	115.7	3904.2	19,529.0	-11.7
1988	14,737,000,000	2340.5	138.7	4681.2	23,405.8	+19.9
1989	18,730,000,000	2974.8	176.3	5949.5	29,748.0	+27.1
1990	21,820,000,000	3465.5	205.4	6931.1	34,655.2	+16.5
1991	24,588,000,000	3905.1	231.4	7810.3	39,051.5	+12.7
1992	25,880,000,000	4110.3	243.6	8293.7	41,103.5	+5.3
1993	26,110,000,000	4146.8	245.7	8293.7	41,468.8	+0.9
1994	26,210,000,000	4162.7	246.7	8325.5	41,627.9	+0.4
1995	26985,000,000	4285.9	254.0	8572.0	42,859.8	+3.0
1996	26,820,000,000	4259.6	252.4	8519.3	42596.4	-0.6
1997	27,056,016,000	4297.1	254.6	8594.3	42,971.0	+0.9
1998	27,294,109,000	4334.9	256.9	8669.9	43,349.5	+0.9
1999	26,502,579,840	4209.2	249.4	8418.5	42,092.3	-2.9

As the world population increases, global energy demand is fast rising. It is projected that the world's energy demand is likely to rise by 54% of current rate by 2025 with a slight drop to about 50% by 2030, although petroleum and other fossil fuels are expected to dominate the global energy market up to at least 2025 (Okoye,2009; Usuman & Tijani, 2007). But beyond

2030, attention would shift to renewable alternatives (Ominigbo,2010b). Presently, 2.4 billion people globally rely on tradition biomass (fuel wood) energy, with Africa alone accounting for 1.6 billion (66.7%) of this figure (Okoye, 2009). In Nigeria, 60% of the populace, particularly in the rural areas uses fuel wood for energy generation (Choji, 2005). Onocha (2011) asserts that the rampant felling and burning of tropical forest trees is the second largest source of GHGs emission in Nigeria.

Studies have shown that the combustion of fuel wood and other fossil fuels have adverse environmental and human health implications. Chronic airway diseases (COAD) and other respiratory diseases have been linked to burning biomass energy in poorly ventilated places (Yakubu & Zagga, 2006). The deforestation of forests for biomass energy has also led to the degrading and disappearance of the country's natural vegetation (Choji, 2005; Akpofure, 2009; Oroka; Anwadike & Uduaghan, 2004; Erhenhi, 2011).

Alternative Energy Sources for Nigeria

Just as Nigeria is endowned with petroleum and other fossil fuels, the country is also richly blessed with many renewable energy sources. Some of the energy sources where Nigeria could potentially excel in the post-fossil fuels era are wind, biodiesels, biogas, solar energy, nuclear, ocean and hydroelectric power (Usuman & Tijani, 2007; Ominigbo, 2010a), figure 1. Most of these energy sources if properly harnessed will not only guarantee efficient energy supply but also ensure economic development especially as the country aims to become one of the 20 largest economies of the world by 2020. For instance, citing the green shield of Nations, Ominigbo, (2010a) asserts that if only 10% of the country's northern landmass is dedicated to the cultivation of *Jatropha curcas* for biodiesels, the country could earn up to 3 billion dollars from such an investment just as Tacio, (2003) opines that there could be potential yield range of 1.25-12.5 tons of seeds per hectare. It must be stressed however, that the Jatropha story may not be entirely the same for the southern forest belt which is already deforested and degraded as a result of agriculture, mineral exploitation and urbanization.

Fig. 1: Nigeria's Fuel and Power Resources

Source: Olayinka (2005)

Similarly, gasohol, a blend of gasoline and alcohol is another important biomass wherein Nigeria can potentially strive. This alternative energy source which could be produced from the non-food parts of grains such as corn; remove the fear of this energy source competing with food security, especially in developing and famine-prone countries (Montgomery, 2003). Also, with the rapid urbanization across the country and its attendant growth in waste generation, Nigeria stands a good chance of generating a sizeable amount of energy from organic wastes. This would not only diversify the country's energy sources, but also help in reducing the problem of environmental pollution resulting from such wastes. And, with Nigeria's strategic location between the equator and tropics of cancer, the country stands to benefit immensely from wind power and solar energy. This is also true of hydroelectric power and tidal power as the country is not just surrounded by rivers but also renowned for many dams-Kainji, Zungeru, Shiroro, Jebba etc.

Conclusion and Recommendations

There is a growing awareness and consciousness that climate change is a reality. And as the global warming and climate change phenomena bite harder, there is a dire need for shift over dependence from fossil fuels to alternative energy sources with a view to mitigating climate change. Nigeria, though endowed with huge petroleum, natural gas and coal deposits, is also potentially rich in many renewable energy sources waiting to be harnessed.

From the foregoing, it is recommended that:

- Government and research institutions should encourage researches aimed at harnessing the country's rich renewable energy potentials;
- Policies and regulations should be made to discourage deforestation and encourage afforestation;
- There should be increased awareness campaigns on the effects of deforestation, particularly among the rural populace;
- The curricular of our schools should be reviewed to include modern climate trends; and
- Landfills should be constructed with a view to collecting organic wastes and processing into biogas energy.

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PERFORMANCE EVALUATION OF TANGIBLE AND INTANGIBLE ENVIRONMENTAL FACTORS FOR SUSTAINABLE PUBLIC HOUSING DEVELOPMENT IN DEVELOPING COUNTRIES

BY

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Abstract

The study was carried out to measure the performance of tangible and intangible environmental factors using occupant satisfaction in public housing estates of Bauchi metropolis, Nigeria, with a view to identify the factors that significantly influences occupants' satisfaction using a post occupancy evaluation method for sustainable public housing development. The objectives of the study were to highlight the condition of the tangible and intangible environmental factors of the neighbourhood, measure the occupants' satisfaction with the factors and correlate same with the overall satisfaction level. The study covered two housing estates of Tambari (300 units) and Gubi housing estates (209 units) developed between 2001 and 2010 in Bauchi metropolis. Questionnaires were administered, collected and validated by personal interview and walk-through observation. SPSS17.0V was used to analyse the data using percentages, correlation, analysis of variance and regression analysis. The percentage analysis showed good condition tangible facilities only in roads and drainages with mean average scores from 3.5 to 4.49. The study revealed that occupants were only satisfied with tangible element of drainage and intangible elements of noise and neighbours, while they were neutral (neither satisfied nor dissatisfied) with other environmental elements covered by the study. The study recommends the application of POE on public housing as an effective instrument towards sustainable housing development in developing countries.

Key words: public housing, post occupancy evaluation, sustainable housing development, developing countries, environmental factors.

1. Back Ground of the Study

Public housing development connotes the intervention of government in the provision of affordable housing to the populace. The major motive of public estate development is social service welfare as against profit maximisation in private estate developments (Ilesanmi, 2010). This implies that the major objective of public housing development is basically in the provision of social services to the public. Therefore, for the public housing to meet its basic objective, it must derive occupants' satisfaction. This comprises of both satisfaction with the physical attributes of the building and the environment where the houses were sited.

Some of the objectives of POE are to generate information on both the short and long term performance results of the design, occupants' satisfaction and other building performance aspects. A POE can play a role in an attempt to determine an acceptable balance between creativity and utility. It does this by bringing in the elements of user satisfaction as well as the actual functioning of the building which together constitutes its utility (Meir et al, 2009). POE also has the potential to clarify discrepancies, loopholes and problems in different ways. They can indicate problems in the design process, the operation (for occupants, users or building managers) or in the building as a system. Despite these advantages mentioned evidence from the literature shows little attention was given to residential building evaluation (Leaman, Stevenson & Bordass, 2010). Djebarni & Al-Abed (2000) pointed that research in the areas of public housing in general is limited, and little attention is given to the variation in the houses and how they affect satisfaction. It was also pointed out by Bordass & Leaman (2005) that even though such studies provide information that are necessary for future use, attention is more given to the design aspects by the evaluation scholars. Even after development, housing performance in respect to the operation and maintenance has to be monitored and the best practice is where the collected feedbacks are effectively utilised in housing improvement (Way & Bordass, 2005). Ozturk, Arayici, & Coates (2012) pointed that "if we fail to adequately learn by evaluating our existing building stock effectively then we fail to avoid avoidable mistakes". There is need to be conducting POE to identify opportunities and pitfalls to improve the overall housing performance (Cohen et al., 2001). Husin et al. (2012) draw attention to the importance of residential building evaluation, by pointing out the failure of scholars to examine social environmental issues such as noise, crime, accidents etc in POE of housing satisfaction. Therefore, this study fills the above gap through a comprehensive survey which covers various tangible and intangible environmental factors influencing performance and satisfaction level of building occupants. Even though so many writers and researchers have conducted Post Occupancy Evaluation on many subjects, such as Meir et al. (2009) who consider POE as an inevitable step towards sustainability; Ilesanmi (2010) conducted study on POE and residents' satisfaction with public housing in Lagos, Nigeria; and Adewunmi et al. (2011) on postgraduate hostel facilities in University of Lagos, no similar study is conducted on public housing developments in Bauchi metropolis, Nigeria.

Jiboye (2010) observed that public housing developments in Nigeria were characterized by lack of adequate thought and consideration on relevant factors or parameters that determine occupants' satisfaction. It is within this context, therefore, that this research seeks to evaluate the success or otherwise of achieving occupants' satisfaction as the basic aim of public housing development in Nigeria, through post occupancy evaluation with particular reference to public housing estates in Bauchi metropolis.

The aim of this research was to conduct Post Occupancy Evaluation on public real estate developments in Bauchi metropolis with a view to ascertain the adequacies or otherwise of public real estate developments with regard to building performance and occupants' satisfaction. In order to achieve this aim, the following objectives were formulated:

i) To identify the condition of the tangible and intangible environmental factors.
ii) To measure the occupants' satisfaction with tangible and intangible environment factors.
iii) To correlate the satisfaction with tangible and intangible factors with the overall satisfaction with houses.

To achieve the objectives of the study, the figure 1 conceptual frame model was forwarded;

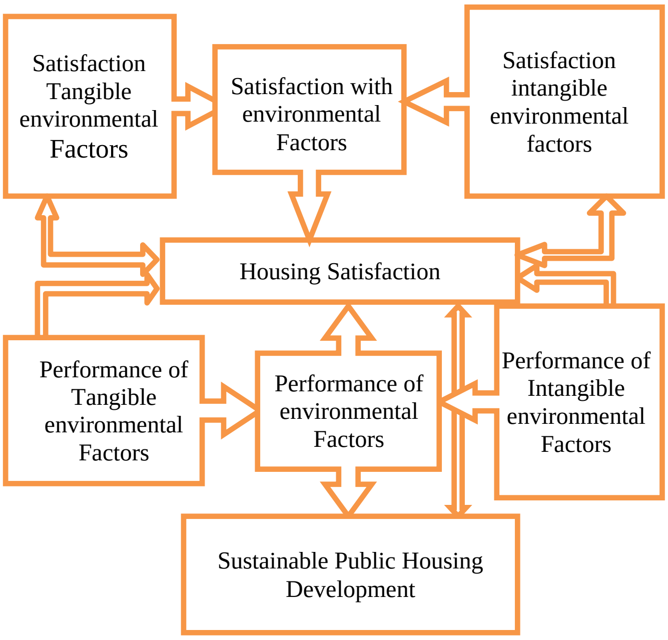

Figure 1: A model for sustainable housing environmental development

2. The Study Area

Bauchi town is located between longitudes 8^0 50' and 11^0 E' and latitudes 9^0 3' and 12^0 3' N in North Eastern part of Nigeria. The town is the capital city of Bauchi State (one of the 36 administrative regions of Nigeria). The Tambari housing estate, one of the estates in this study is located besides Abubakar Tatari Ali Polytechnics, along Bauchi-Jos road, Bauchi. It was developed by Bauchi state government. The scheme was acquired at the cost of N40, 000,000 (forty million Naira only) in the year 2000 from the Federal government. The Bauchi state government built 300 units with two (2) bedrooms and three (3) bedrooms and allocated to civil servants on the owner occupier basis at the cost of N1.8million and N1.2million for three (3) bedrooms and two (2) bedrooms respectively. Two (2) bedrooms were allocated to the junior cadre on grade level 8 and below, while three (3) bedrooms were allocated to senior cadre staff (level 9 and above). Selection of the occupiers was through balloting.

The Gubi housing estate, the second estate in this study is located at the East of the town, behind the Kari housing estate, along Bauchi-Maiduguri road Bauchi. This housing estate was first conceived under the federal government housing scheme with a target to build 1,000 housing units from 1980-1983. However, the project was then abandoned. The project was taken over by Bauchi state government in the year 2000 and completed the construction of 209 houses comprising three (3) and four (4) bedrooms. The completed scheme was sold to citizens on cash and carry basis, initially, at N3.5million and N4million for three (3) bedrooms and four (4) bedrooms respectively.

3. Methodology

For the purpose of this research, the population comprises of the 509 public housing units developed in Gubi and Tambari housing estates between 2000 and 2010. Random sampling technique (=INT (509*RAND ()) +1) was used to choose the sample of 302 housing units which were used in the study. Systematic sampling was used in identifying the housing units to administer the questionnaires, whereby two units of houses were taken in every three housing units. Direct observation was conducted by personal visit to the sampled housing units to extract relevant information on the physical characteristics of the housing units such as state of repairs, visual quality, services, neighbourhood, etc. The questionnaire involved close ended questions to enable the researcher collect all the details sought.

4. Data Presentation and Analysis

Tables were used to present data collected. The Statistical Package for Social Science (SPSS) 17.0 was used to analyse data using frequencies, percentages, correlation, analysis of variance (ANOVA) and regression analyses.

4.1 Conditions of Neighbourhood Amenities and Services

This section measured the conditions of neighbourhood components and services. To be able to quantify the degree of condition for each criterion of performance, the following scale of 1-5 were used.

a). The condition is very good if the mean score is between 4.5-5.
b). The condition is good if the mean score is between 3.5 and 4.49.
c). The condition is fair if the mean score is between 2.5 and 3.49.
d). The condition is poor if the mean score is between 1.5 and 2.49.
e). The condition is very poor if the mean score is less than 1.49.

Table 1: Conditions of Neighbourhood Amenities and Services

Facilities	VG (5)	G (4)	F (3)	P (2)	VP (1)	Mean scores
Access road	92(45.5)	62(30.7)	28(13.9)	16(7.9)	4(2)	4.10
Drainage system	56(27.7)	82(40.6)	38(18.8)	10(5)	16(7.9)	3.75
Water supply	86(42.6)	-	-	-	116(57.4)	2.70
Electricity supply	34(16.8)	-	-	-	168(83.2)	1.67
Security	16(7.9)	62(30.7)	64(31.7)	32(15.8)	28(13.9)	3.03
Sanitation	28(13.9)	70(34.7)	62(30.7)	24(11.9)	18(8.9)	3.33
Greening	8(4)	50(24.8)	58(28.7)	56(27.7)	30(14.9)	2.75

VG=Very Good, G= Good, F= Fair, P= Poor, VP= Very Poor

As shown in table 1, the study revealed that condition of the tangible elements of access road and drainage system were good as their mean score range from 3.5 to 4.49. The study also found that the conditions of the tangible elements of water supply and greening, and intangible elements of security and sanitation were fair as their mean score fall within the range 2.5 to 3.49. The condition of electricity supply was ranked poor as it has a mean score of 1.67 which fall within the range of 1.5 to 2.49.

4.2 Occupants' Satisfaction with Neighbourhood

To be able to quantify the degree of satisfaction of the occupants for each criterion of performance, the following graduated scale of 1-5 were used.

a). The very satisfied is the mean score between 4.5-5.
b). The satisfied is the mean score between 3.5 and 4.49.
c). The neutral (neither satisfied nor dissatisfied) is the mean score between 2.5 and 3.49.
d). The dissatisfied is the mean score between 1.5 and 2.49.
e). The very dissatisfied is mean score less than 1.49.

TABLE 2: Occupants' Satisfaction with Tangible Environmental Factors

	VS (5)	S (4)	N (3)	D (2)	VD (1)	Mean scores
Drainage	40(19.8)	98(48.5)	48(23.8)	14(6.9)	2(1)	3.79
Water supply	18(8.9)	66(32.7)	50(24.8)	50(24.8)	18(8.9)	3.08
Electricity supply	6(3)	36(17.8)	70(34.7)	70(34.7)	20(9.9)	2.69
Closeness to school	20(9.9)	86(42.6)	62(30.7)	34(16.8)	-	3.46
Closeness to hospital	12(5.9)	40(19.8)	68(33.7)	48(23.8)	34(16.8)	2.74

Closeness to market	6(3)	40(19.8)	72(35.6)	56(27.7)	28(13.9)	2.70
Close. to recreation centres	6(3)	54(26.7)	62(30.7)	50(24.8)	30(14.9)	2.47
Close. to waste disposal centres	6(3)	54(26.7)	62(30.7)	50(24.8)	30(14.9)	2.78
Greening	8(4)	50(24.8)	74(36.6)	52(25.7)	18(8.9)	2.89
Overall environment	52(25.7)	88(43.6)	50(24.8)	12(5.9)	-	3.89

VS= Very satisfied, S= Satisfied, N= Neutral, D= Dissatisfied, VD= Very Dissatisfied

The table 2 presents occupants level of satisfaction with tangible environmental factors, it indicated that they were 'satisfied' with drainage system available in the neighbourhood. Their responses on water supply, electricity supply, closeness to school, hospital, market, recreation centres and waste disposal centres were ranked 'neutral' (neither satisfied nor dissatisfied) with mean score between 2.5 to 3.49. The overall satisfaction level was ranked satisfied with 3.89 mean score.

TABLE 3: Occupants' Satisfaction with Intangible Environmental Factors

	VS (5)	S (4)	N (3)	D (2)	VD (1)	Mean scores
Security	16(7.9)	68(33.7)	52(25.7)	40(19.8)	26(12.9)	3.04
Sanitation	20(9.9)	78(38.6)	52(25.7)	38(18.8)	14(6.9)	3.26
Level of noise	30(14.9)	96(47.5)	52(25.7)	16(7.9)	8(4)	3.61
Neighbours	46(22.8)	110(54.5	38(18.8)	6(3)	2(1)	3.95
Overall environment	52(25.7)	88(43.6)	50(24.8)	12(5.9)	-	3.89

VS= Very satisfied, S= Satisfied, N= Neutral, D= Dissatisfied, VD= Very Dissatisfied

Responds in table 3 on occupants' satisfaction with intangible factors indicated 'satisfied' with the level of noise and neighbours. The responses on security and sanitation were ranked 'neutral' (neither satisfied nor satisfied) with mean scores between 2.5 to 3.49.

4.3 Assessment of Significance

Correlation analysis was used to determine if there is a significant relationship between satisfaction with tangible and intangible elements of the house and overall satisfaction with the houses. Those elements with significant correlations were subjected to regression and ANOVA analysis.

Table 4: Correlation Analysis of Overall Satisfaction with Environment and Satisfaction with Tangible and Intangible Elements of the environment

Satisfaction with;	**Pearson Correlation**	**Sig. (2-Tailed)**
Drainage	0.289**	0.000
Water supply	0.388**	0.000
Electricity supply	0.293**	0.000
Closeness to schools	0.288**	0.000
Closeness to hospitals	0.176*	0.012
Closeness to markets	0.076	0.284
Closeness to recreation centres	0.340**	0.000
Closeness to waste disposal centres	0.220**	0.002
Greening	0.252**	0.000
Level of security	0.213**	0.002
Sanitation	0.297**	0.000
Level of noise	0.129	0.067
Neighbours	0.330**	0.000

** Correlation is Significant at 0.01 Level (2-Tailed) *Correlation is Significant at 0.05 Level (2-Tailed)

The correlation analysis in table 4 revealed a positive and significant relationship between overall satisfaction with neighbourhood and satisfaction with both tangible and intangible elements of environment (neighbourhood) except satisfaction with tangible factor of closeness to markets and intangible factor of level of noise which have correlation of 0.076 and 0.129 with p-value of 0.284 and 0.067 respectively. Correlations with satisfaction with drainage, water supply, electricity supply, closeness to schools, and closeness to recreation centres, closeness to waste disposal centres, level of security, sanitation, greening, and neighbours were significant at 0.01 level. However, correlation with satisfaction with closeness to hospital was significant at 0.05 level.

These correlations were further subjected to regression analysis in order to determine the level of interaction between overall satisfaction with the environment and satisfaction with individual elements of the environment.

Table 5: Regression Model on Overall Satisfaction with Environment and Satisfaction with Tangible and Intangible Elements of the environment

R	R Square	Adjusted R Square	Std. Error of the Estimate
.578[a]	.334	.288	.723

[a]Predictors: (Constant), satisfaction with neighbours, level of security, greening, closeness to schools, level of noise, drainage, closeness to market, waste disposal centres, water supply, level of sanitation, electricity supply, closeness to recreational centres and satisfaction with closeness to hospitals.

Table 5 indicates the model summary of the regression analysis with R-value (correlation) of 0.578 (57.8%), R-squared value of 0.334 and standard error of estimate of 0.723. The R-squared value (coefficient of determination) of regression analysis indicates that 33.4% of the variation in overall satisfaction with the environment (neighbourhood) was contributed (determined) by satisfaction with individual elements of the environment. This indicates that the sum of satisfaction with tangible and intangible elements of neighbourhood made up the overall satisfaction with estates.

Table 6: ANOVA Test on Overall Satisfaction with Environment and Satisfaction with Tangible and Intangible Elements of the environment

	Sum of Squares	df	Mean Square	F	Sig.
Regression	49.350	13	3.796	7.264	.000[a]
Residual	98.254	188	.523		
Total	147.604	201			

Table 6 indicates the analysis of variance (ANOVA) which explains the linear relationships and level of significance between dependant variable (overall satisfaction with the estate) and the predictors (tangible and intangible elements). The analysis yielded an F-ratio of 7.264 with degree of freedom (df) at 13 with p-value of 0.000. This shows that the level of relationship of predictors to overall satisfaction with the environment is significant at 0.01 significance level.

Table 7: Regression Coefficients of Overall Satisfaction with Environment and Satisfaction with Tangible and Intangible Elements of the environment

Satisfaction with:	**Unstandardized Coefficients**		**Standardized Coefficients**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	1.576	.345		4.571	.000
Drainage	.088	.074	.089	1.190	.235
Water supply	.145	.064	.192	2.267	.025
Electricity supply	.066	.076	.076	.871	.385
Closeness to schools	.160	.067	.166	2.385	.018
Closeness to hospitals	.200	.092	.265	2.168	.031
Closeness to market	-.384	.096	-.463	-4.010	.000
Closeness to recreation centres	.253	.075	.324	3.363	.001
Closeness waste disposal centres	-.112	.074	-.142	-1.507	.134
Greening	-.068	.071	-.079	-.957	.340
Level of security	.016	.059	.022	.270	.788
Level of sanitation	.079	.067	.101	1.189	.236
Level of noise	.058	.065	.066	.890	.375
Neighbours	.167	.086	.154	1.940	.054

[a]Dependent Variable: Overall Satisfaction with the Environment

Table 7 presents the regression coefficients. The highest beta weight was found with satisfaction with a tangible factor of closeness to recreational centres (0.324) while the least beta weight was found with satisfaction with the intangible factor of noise level (0.066).

Table 8: Correlation Analysis of Overall Satisfaction with the Environment and Performance of Tangible and Intangible Elements of the Environment

Predictors	Pearson correlation	Sig.(2-tailed)
Accessibility	-0.30	0.667
Condition of access road	-0.10	0.886
Drainage	-0.49	0.489
Condition of drainage	0.124	0.079
Major source of water supply	-0.048	0.502
Condition of water supply	0.250**	0.000
Major source of electricity	0.007	0.917
Condition of electricity supply	0.119	0.091
Closeness to schools	0.454**	0.000
Closeness to hospitals	0.122	0.083
Closeness to markets	0.155*	0.028
Closeness to recreation centres	0.179*	0.011
Closeness to waste disposal centres	-0.011	0.878
Greening	0.287**	0.000
Security	0.254**	0.000
Sanitation	0.356**	0.000

**significant at 0.01 level (2-tailed) *significant at 0.05 level (2-tailed)

As shown in table 8, there are significant correlations between satisfaction with the environment (estate) and performances of condition of tangible factor of water supply, closeness to schools, level of security, greening and intangible factors of security and sanitation at 0.01 level of significance.
Similarly, the analysis found significant correlations between satisfaction with the environment and performances of closeness to markets and recreational centres at 0.05 level of significance.
However, the study found no significant correlation between satisfaction with the environment (estate) and performances of tangible factors like accessibility, condition of accessibility, drainage, condition of drainage, major source of water, major source of electricity, condition of electricity, closeness to hospitals, and closeness to waste disposal centres as their p-values are above 0.05.

Table 9: Regression Model of Overall Satisfaction with the Environment and Performance of Tangible and Intangible Elements of the Environment

R	R Square	Adjusted R Square	Std. Error of the Estimate
.587[a]	.345	.289	.723

a. Predictors: (Constant), level of greening, condition of the access road, a major source of water, major source of electricity, drainage system, closeness to market, regularity of water supply, closeness to waste disposal centres, level of security, regularity of electricity, closeness to schools, accessibility (road), closeness to recreation centres, level of sanitation, condition of drainage, closeness to hospitals.

Table 9 indicates summary of the regression analysis model with R-value of 0.587, R-squared value of 0.345 and standard error of estimate of 0.723. The R-squared value (coefficient of determination) of regression analysis indicates that 34.5% of the variation in overall satisfaction with environment was determined by the environmental performance. This indicates 34.5% relationship between satisfaction with the environment and the performances of tangible and intangible environmental factors.

Table 10: ANOVA Test on Overall Satisfaction with the Environment and Performance of Tangible and Intangible Elements of the Environment

	Sum of Squares	df	Mean Square	F	Sig.
Regression	50.946	16	3.184	6.094	.000[a]
Residual	96.658	185	.522		
Total	147.604	201			

Table 10 indicates the analysis of variance (ANOVA) which explains the linear relationship and the level of significance between dependant variable (overall satisfaction with the environment) and the predictors (tangible and intangible factors). The analysis yielded an F-value of 6.094 with degree of freedom (df) at 16 with p-value of 0.000. This shows that the level of relationship between performances of tangible and intangible factors of the environment and overall satisfaction with the environment is significant at 0.01 significance level.

Table 11: Regression Coefficients of Overall Satisfaction with the Environment and Performance of Tangible and Intangible Elements of the Environment

Predictors	**Unstandardized Coefficients**		**Standardized Coefficients**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	2.970	.412		7.203	.000
Accessibility (road)	.100	.047	.159	2.119	.035
Condition of access	-.054	.063	-.066	-.861	.390
Drainage system	-.233	.061	-.366	-3.846	.000
Condition of drainage	.141	.071	.189	1.992	.048
Major source of water	.000	.052	.000	-.014	.989
Regularity of water	.055	.034	.127	1.631	.105
Major source of electricity	-.100	.055	-.116	-1.815	.071
Regularity of electricity	.002	.045	.004	.046	.963
Closeness to schools	.267	.059	.356	4.512	.000
Closeness to hospitals	-.246	.074	-.460	-3.304	.001
Closeness to market	.187	.072	.342	2.574	.011
Closeness to recreation centres	.072	.055	.115	1.298	.196
Closeness to waste disposal centres	-.116	.054	-.171	-2.147	.033
Level of greening	.023	.064	.030	.365	.715
Level of security	.090	.061	.121	1.479	.141
Level of sanitation	.120	.069	.159	1.749	.082

[a]Dependent Variable: overall satisfaction with the estate

As shown in table 11, the highest beta weight was found with tangible factors of closeness to schools (3.56) followed by drainage (-3.66) while the least beta weight was found with the major source of water supply and regularity of electricity (-0.012) and (0.046) respectively.

5. Findings, Recommendation and Conclusion

The study revealed that the condition of the tangible elements of access road and drainage system were good and the conditions of the tangible elements of water supply and greening, and intangible elements of security and sanitation were fair. It is the condition of electricity supply that was rated poor by the study. Even though the overall satisfaction level with the neighbourhood was ranked satisfied, the occupants were only satisfied with one tangible element which is the drainage system available in the neighbourhood. Their responses on water supply, electricity supply, closeness to school, hospital, market, recreation centres and waste disposal centres was neutral (neither satisfied nor dissatisfied). In the other hand, they were satisfied with two intangible elements which are the level of noise and neighbours, while security and sanitation were ranked neutral (neither satisfied nor satisfied).

The study further revealed that there is positive and significant relationship between overall satisfaction with neighbourhood and satisfaction with both tangible and intangible elements of environment, except satisfaction with tangible factor of closeness to markets and intangible factor of level of noise. However, satisfaction with drainage, water supply, electricity supply, closeness to schools, and closeness to recreation centres, closeness to waste disposal centres, closeness to hospital, level of security, sanitation, greening, and neighbours were found out to be significant. The study also discovered that 33.4% of the variation in overall satisfaction with the environment (neighbourhood) was contributed (determined) by satisfaction with individual elements of the environment examined. This indicates that the sum of satisfaction with tangible and intangible elements of neighbourhood made up the overall satisfaction with estates, therefore the level of relationship of predictors to overall satisfaction with the environment is significant.

Meanwhile, the study indicated significant correlations between satisfaction with the environment (estate) and performance condition of tangible factors of water supply, closeness to schools, closeness to markets, recreational centres, level of security, greening and intangible factors of security and sanitation. However, there is no significant correlation between satisfaction with the environment (estate) and performances of tangible factors of accessibility, condition of accessibility, drainage, condition of drainage, major source of water, major source of electricity, condition of electricity, closeness to hospitals, and closeness to waste disposal centres. It was further revealed that 34.5% of the variation in overall satisfaction with environment was determined by the environmental performance. This indicates 34.5% relationship between satisfaction with the environment and the performances of tangible and intangible environmental factors, therefore the level of relationship between performances of tangible and intangible factors of the environment and overall satisfaction with the environment is significant.

Hence, adequate and immediate remedial measures should be applied to electricity supply. Alternative sources of electricity should be sought by occupants to supplement the existing sources. If the alternative source is to serve the whole neighbourhood, then a giant generator that can serve the neighbourhood can be used. However, if the alternative is on individual basis, then solar panels and inverters which are environmentally friendly should be used. The issues of security and sanitation need to be improved collectively at community level. The community can organise a local security group to boost the government effort. Periodic community sanitation day can be set, whereby the occupants will devote time to sanitise their houses and the surrounding neighbourhood. Adequate greening (landscaping) should be made to make the environment aesthetically appealing. Even though, the condition of access road and drainage system were rated good, there is need to ensure effective management to preserve their condition. Drainages should be evacuated periodically to prevent the danger of blockage and collapse. The need for employment of professional estate and facility managers to manage such housing estates is visible at this stage, for sustainability. All the recommendations mentioned above can be effectively facilitated if such houses were under supervision of estate and facility managers.

Meanwhile, those findings also serve as a guide to public housing policy makers and their building design teams to envisage the areas of public housing weaknesses and use it as precaution in future developments for sustainable public housing developments. This is further strengthened by the other findings of this study. The fact that occupants were satisfied only with only (1) tangible (drainage system) out of nine (9) and two intangible (level of noise and neighbours) out of four (4) environmental factors examined indicated the need for the public housing policy makers and design teams to improve the priority given on both tangible and intangible environmental factors. This recommendation is further strengthened by the other findings that there is positive and significant relationship between overall satisfaction with neighbourhood and satisfaction with both tangible and intangible elements of environment using correlation, regression analysis and analysis of variance (ANOVA).

However, the findings of this study portrayed the importance and relevance of POE to sustainable public housing development especially in developing countries like Nigeria. POE serve as effective instrument of measuring the housing performance both on individual components, whether tangible or intangible, and the overall housing as a bundle as indicated in this study. Therefore, the use of POE on public housing development has become necessary to identify areas of weakness and guide future developments. Further research should be conducted to identify the relevance and effect of physical attributes of the building on the satisfaction level with public housing developments.

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Policy Instruments for Reducing Nitrogen Emission from Fertilizer use: Under Policy Conflict of Self Sufficiency of Food versus Sustainable Management of Agriculture.

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Abstract

The paper discuss an alternative policy instrument for reducing nitrogen emission from fertilizer use in agriculture compared to existing fertilizer subsidy for food self sufficiency policy. The relative efficiency of fertilizer subsidy policy assessed in terms of budgetary resource and sustainable management of agriculture. It concern of nitrogen leaching and atmospheric emission control as climate change adaptation. An analytical framework of ex-post evaluation is developed to assess the alternative incentive policies instead of fertilizer subsidy in Bangladesh. It observed that at the preliminary phase fertilizer subsidy policy efficiently contribute to increase food production. Recently marginal productivity of fertilizer found zero or even negative. Although distributional implication of inputs subsidy is quite high but over dozes of cheap fertilization seriously emit the air as well as hampered water quality and soil. Finally, the implication of results suggests that for any reduction of nitrogen emission from agriculture, the policy planner could explore the direct incentives programme instead of subsidized fertilizer any more.
Key Words: Policy instruments, sustainable management, nitrogen emission, ex-post evaluation, subsidy, climate change.

1. Introduction

Inefficient or over application of fertilizer are now a days, a major problem. Some research finding claimed 70 percent of nitrogen fertilizer applied to crops in developing country is lost to runoff or released into the atmosphere that's contributing coastal "dead zones" and global warming, surface water quality degradation (IFDC 2011).

Under the policy goal of food self sufficiency, most of agriculture inputs like chemical fertilizer were subsidized in Bangladesh. After introduction of HYV rice production technology, chemical fertilizer critically raising the crop yields inevitably. Effort of last three decades all the policy instruments more or less favor for attaining the self sufficiency in food production. It time to re-thinking or review existing support policy in the context of global climate change and environmental concern. Especially intensive use of chemical fertilizer substantially creates environmental degradation and atmospheric emission. Moreover most of the countries are conscious about environmental quality, service and adopt sustainable environmental policy.

The agricultural sector is the largest source of N_2O emissions. There are about 46 percent of anthropogenic emissions occurred from the oxides of nitrogen (IPCC, 1995). It is an important long-lived greenhouse gas that is emitted predominantly by biological sources in soil and water. The N_2O is also primary source in the stratosphere of the oxides of nitrogen, which play a critical role in controlling the abundance and distribution of stratospheric ozone.

Estimates from ice core measurements suggest that the pre-industrial atmospheric concentration of N_2O was about 275 ppb (with a range of 260 to 285 ppb). By 1994 this had increased by about 15 percent to a level of 312 ppb (IPCC, 1995). Direct emissions comes from soil nitrogen e.g. applied fertilizers mainly urea (both manures and artificial), the mineralization of organic soils and crop residues;

The soil is getting weaker and weaker over the last 10 to 15 years over the world with fertilization (FAO 1996). We need more and more urea to get the same yield. The over use of urea is so degrading to soil that yields on some crops are falling and import levels are raising (IFDC 2011)

Under the sustainable agriculture management policy, environment friendly agricultural practices is to be encouraged and ensured for attainment of self-sufficiency in food at the same time. Among the various specific measures, use of natural fertilizers and insecticides is encouraged as opposed to the application of agro-chemicals and artificial materials that are exerting adverse impact on the environment.

Sudden control by sustainable management of agriculture for reducing the chemical fertilizer use will hammer crop production as well as food self sufficiency goal. In these circumstances, what is the optimum solution under policy conflict of self sufficiency of food and nitrogen emission reduction through urea use controlled? The paper will try to find through an ex-entry evaluation of available policy instruments in this regard.

2. Methodology

A desk study has been carried out for assessing current nitrogen emission from fertilizer use and fertilizer subsidy policy for self sufficiency of food. Based on published and unpublished papers of IPCC, FAO as well as food and agricultural policy documents of Bangladesh were used to analyze the research phenomena of the study. The alternative policy options oppose to input subsidy policy analysis is a major focus of the study. Which includes the rationale and systematic analysis of subsidy policy for be validated or refuted in the ground of sustainable use of fertilizer and agro-chemicals. The discussion of input subsidy policy consists of a number of sub-sections; these are as follows, discussion of the recent trend of fertilizer subsidy, investigation of rationale for subsidy and deals with the issue of justification of subsidy. In addition to this an ex-ante evaluation of some successful regional and international policy instruments that aiming at reducing nitrogen from fertilizer use assessed in the context of Bangladesh.

The following policy instruments have been analyzed qualitatively.

Withdrawal of existing fertilizer subsidy:

It is intervention to prevent world market price fluctuation of fertilizer through direct compensation payment for volatile price by assistant card according to area allocation to crop.

Introduction of certification system as well as incentive for Fertilizer Best Management Practice of climate change adapted farms.

Regulations are imposed for fixing nitrogen vulnerable zone and ceiling of nitrogen/ha application.

Provision of enhancing knowledge based through extension.

Finally the feasibility of policy instruments is analyzed under the policy goal of self-sufficiency. It also assumes that the policy combination will fully implemented without penetration and adoption measure in the practice.

3. Discussion

3.1 Assessment of existing fertilizer subsidy policy

Many developing countries have used inputs subsidies to encourage the use of fertilizer and to offset the effects of low crop prices, often set by the government or the crop-purchasing. In a survey of 38 developing countries, FAO (1996) found that 68 percent of them used fertilizer subsidies. Although subsidies can be a useful policy tool during the introduction of fertilizers to the market, the danger is that they become entrenched. After achievement, subsidies are difficult to phase out at a later stage when they are no longer required.

Economic reasoning for providing subsidy for fertilizer are ensure cheaper agricultural input, higher production of food grain target, lower price of staple for higher food security. It helps closer to self-sufficiency in food grain production, less vulnerability to risks of facing high prices of import in the world market (Barkat et.el.2010)

On the contrary, economic reasoning for not providing subsidy for fertilizer is an "*inefficient*" allocation of resource in the sense that farmers pay for fertilizer a lower price compared to the world price of fertilizer. It is therefore, more incentive to use too much of fertilizer (see Osmani and Quasem (1990). Continuing with subsidies beyond the introductory phase encourages the wasteful use of fertilizers and it means that the bigger, healthier farmers reap most of the benefits. Experience in Bangladesh showed that a well managed phasing out of fertilizer subsidies can be achieved without causing a major setback to fertilizer consumption ((Barkat et.el.2010)

There is a system loss for target group benefit. Because some other industrial use of urea like tobacco industry reaping the benefit of subsidized fertilizer but nothing paid to society. In addition to this illegal border trade of fertilizer with Myanmar and India where urea price is higher easily flow of this and substantially make budgetary pressure to the government. The key is to synchronize the subsidy removal with the development of a competitive market, which promotes increased efficiency and lower costs.

Yet the counterargument to the second line of argument is with market imperfections such as low access to credit as well as liquidity constraints, farmers already face "*inefficiency*" in allocation of resources, find it difficult to finance fertilizer purchases, and therefore without "*subsidy*" would be using suboptimal amount of fertilizers. Therefore "*subsidy*" is not necessarily introducing "*inefficiency*" in an "*efficient*" world, but may be considered as a "*correcting device*" to address issues of imperfections in the developing country agricultural sector.

There is some political reasoning for providing subsidy for fertilizer; these are requirement of a democratically elected government to meet election pledges for "cheap rice". Since Bangladeshi households are, on average, net buyers of rice, it may be politically costly for the government not to be able to keep rice prices low.

Therefore, the subsidy related literature has two strands of arguments. One is that subsidy for fertilizer keeps prices of fertilizers artificially low as compared to the world price of fertilizers, thus creating an incentive for farmers to use more-than-optimal amount of fertilizers, and this creates inefficiency in the allocation of resources. One can bolster this argument by further adding that farmers actually receive fertilizer subsidy in two stages; one is at the stage of production of fertilizer itself, since the natural gas used to manufacture urea is sold to the five fertilizer factories at a subsidized rate, and the other is the ex-factory price of urea fertilizer dealers need to pay is lower than the cost of production of one unit of urea.

The other argument is that, as it is mentioned earlier, *subsidy* is a form of correcting device for existing market imperfections in the food grain production sector.

Finally, current subsidies on urea have a harmful effect by encouraging relatively more nitrogenous fertilizer to be used. Additions of nitrogen fertilizer alone can give a short-term boost to yields, but only at the cost of further depleting other nutrients and emits the atmosphere and ground or surface water. Under the changing climate condition the net effect of nitrogen fertilizer is unpredictable. The urea application is 32 percent higher from balance dozes that are concentration of rice production (FAO 1996)

All kind of market failure or inefficiencies are possible to remove through combination of some policy instruments and commitments of the community. Optimum solution of balance between environmental sustainability and food self-sufficiency could be found with cautious gradual implementation of policy mix described in the next section. Another consideration is to phase the policy change at the beginning of a general downturn in the international fertilizer prices.

3.2 Policy Instruments for reducing nitrogen emission.

Environmentally sound agricultural practices are to be encouraged and ensured for attainment of self-sufficiency in food is one of the major policy goal in Bangladesh. Among the various specific measures, use of natural fertilizers and insecticides is encouraged as opposed to the application of agro-chemicals and artificial materials exerting adverse impact on the environment. Considering the sensitivity of existing food policy, agriculture policy and environmental policy are a combination of management option and policy instrument option might help substantial reduction of emission without hampering the production. These are summaries in following two tables 1 and 2.

3.2.1 Management options as adaptation.

Crop management option is the lowering or optimizing of fertilizer application rate to crop grown. On the nutrient management side, nitrogen management emphasizes the synchronization of N supply and crop nitrogen demand. The nitrogen fertilizer applications can be split to match crop requirements at different growth stages, based on the total fertilizer N rate required at the specific sites; to minimize N losses from the soil-plant system. These are managing with irrigation and soil P^H management. It should be maintained by the fertilizer efficiency management practice which is described below.

Table 1 Fertilizer Best Management Practice (FBMP) options influencing emission reduction.

Name of Options	Management options
1. Crop management	(a) Change in fertilizer application rates (b) Irrigation management (c) Soil p^H management
2. Fertilizer efficiency management	(a) Controlled release rate (coating to limit or retard water solubility) (b) Fertilizer placement and timing (e.g Granules form in the middle of row)

Under the option of fertilizer efficiency management, controlling release rate by deep-placed N is in a chemically available form (NH4+-N) in the proximity of the placement site. The uptake of deep-placed N can be elongated by placing the USG (Urea Supper Granule) at lower depths and away from the plant. With USG, recovery of deep placed N in wetland rice is greater than the N recovery from surface applied and/or incorporated ordinary urea.

Fertilizer recovery in the wetland rice plant tops is found significantly higher for deep placed as USG/UMG/15N (50-60%) than for split – applied Urea 15N (25-34%). About 40% nitrogen can be saved by using USG or UMG (Urea Supper Granule) in rice and 20% in vegetable and fruit crops (viz. cabbage, cauliflower, tomato, potato and papaya)(IFDC 2011)

USG and UMG are used to increase nitrogen use efficiency. Urea Super Granules (USG) are small (0.9 g) and Urea Mega Granules (UMG) are large sized (1.8 or 2.7 g) pellets made of ordinary granular urea by compressing. The amount of USG or UMG should be adjusted to the recommended dose of N for different crops and soils. The granules (USG/UMG) need to be placed after 5-7 days of transplanting of rice at 8-10 cm soil depth at the centre of every four hills between rows 1 and 2, between rows 3 and 4, and so on. Recommended numbers of USG ball for each vegetable plant should be applied at 6-10 cm apart from base of plant and into 6-8 cm deep as ring method at 10-15 days after transplanting (IFDC 2011)

The main benefit of USG/UMG placement is that N losses through NH3 volatilization, nitrification, de-nitrification and runoff are significantly minimized. Deep-placed N as USG/UMG is less subject to algal immobilization and uptake by aquatic needs than broadcast and/or incorporated urea. These two factors contribute to the improved nitrogen use efficiency (NUE=60%) of USG/UMG in the wetland rice (IFDC 2011)

3.2.2 Policy Instruments

The better implementation of nitrogen emission reduction from fertilizer application practice could be governed by the following policy instruments in table 2.

Use of chemical fertilizers in the Asian region has increased considerably in recent years. Application of fertilizers per unit area is the maximum in Korea followed by China and the minimum in Myanmar. During the past few years, total fertilizer use in Bangladesh has increased significantly. A further increase in fertilizer use needs to occur in those countries where more production has to be realized from the limited areas of land. The increasing trend of fertilizer use, particularly urea-N, still continues and it is 80 percent higher of other organic fertilizer. Because of N fertilizer found comparatively cheap for agricultural production. The scientist claim that use of urea per hectare per year is over the optimum. (BARC, 2005).

For nitrogen emission control usually EU country and U.S. used tax on fertilizer but in Bangladesh, the country has a very sensitive to food security issue to handle by the government. Therefore most feasible way of fertilizer emission controlled through economic or market based instrument is abolishment of existing subsidy policy of fertilizer. These instruments at least ensure optimum allocation of fertilizer and reduce nitrogen release in technical point of view. In farmer's point of view the subsidy withdrawal policy instruments helps to reduce N use keeping the maximum attainable output by assumption of following mathematical formulation of two factor least cost combination.

Assume, Cob Douglas production function $Y= AH^{\alpha} F^{\beta}$ ………………………………………….. (1)

Where Y= output, A= constant, H= labor F = fertilizer α=elasticity of production in response to labor β= elasticity of production in response to fertilizer.

Given the iso-cost line $C = wH+P_mF$…………………………………………………………… (2)
W= wage rate P_m= market price

Therefore maximizing $Y= A.H^{\alpha}. F^{\beta}$ Subject to $C = wH+P_mF$ by using Lagranzian as:

$L= AH^{\alpha}F^{\beta} + \lambda(C- wH-P_mF)$

Now FOC (First Order Condition)

$$\frac{\partial L}{\partial H} = A\alpha H^{\alpha-1}F^{\beta} - \lambda w = 0 \ldots\ldots (3)$$

$$\frac{\partial L}{\partial F} = A\beta H^{\alpha}F^{\beta-1} - \lambda P_m = 0 \ldots\ldots (4)$$

From equation 3 and 4 optimum H and F found
$H=(\alpha P_m F)/w$
$F=(\beta wH)/P_m$

When we consider subsidy constraint function would be $C=wH+(P_m-S)F$…………………………...(5)

S= per unit of fertilizer subsidy.

Therefore with the subsidy, maximizing $Y= AH^{\alpha} F^{\beta}$ Subject to $C = wH+(P_m-S) F$

FOC

$$\frac{\partial L}{\partial H} = A\alpha H^{\alpha-1}F^{\beta} - \lambda w = 0 \text{ Same as before.}$$

$$\frac{\partial L}{\partial F} = A\beta H^{\alpha}F^{\beta-1} - \lambda(P_m - S) = 0 \ldots\ldots (6)$$

From equation (3) $\lambda= (A\alpha H^{\alpha-1}F^{\beta})/w$ or $\lambda= \alpha Y/wH$…………………………………………..…(7)
From equation (6) $\lambda= (A\beta H^{\alpha}F^{\beta-1})/(P_m + S)$ or $\lambda= \beta Y/F(P_m - S)$……………………………..... (8)

From equation (7) and (8) optimum allocation of fertilizer could be found when it is subsidized derived as:

$F= (\beta wH)/((P_m - S)$ ……………………………………………………………………………….(9)

Therefore if we compare two case with subsidy and abolishment of subsidy
Optimum fertilizer allocation is $(\beta wH)/((P_m - S)$ (with subsidy) $> (\beta wH)/Pm$ (withdrawal of subsidy).
The abolishment of subsidy is a significant policy instrument of nitrogen use control without hampering the threshold output.

Table 2: The feasible policy instruments for nitrogen emission reduction by implement of FBMP.

Type of policy options	Instrument
Economic or Market based instrument.	Removing existing fertilizer subsidy Intervention to prevent world market price fluctuation of fertilizer through direct compensation payment for volatile price by assistant card according to area allocation to crop. Certification as well as incentive for FBMP.
Regulation (restrictions on nitrogen and crop management).	Fixing nitrate vulnerable zones. Ceiling on nitrogen /ha applications. according to recommended dozes in AEZ Restriction on broadcast application encourage granular form application
Enhancing the knowledge base	Funding on Scientific research Extension service (dissemination, codes of good practice etc. Awareness building.

Different study argued that willingness to pay for urea price is higher than the existing subsidized price if they get the supply timely. So there will be a possible risk of timely availability of urea at fair price because of world market price of fertilizer is volatile in nature. The agricultural support is always necessary for subsistence farming but not in the input subsidy form. The farer facing liquidity problem in production season, if the market price of fertilizer raises abnormally their inputs use will be sub optimal. That will hamper the production as a whole and aggravate the food security problem.

To overcome the problem compensation payment system will work as effective policy instruments. The government provides compensation payment for unanticipated price hike of inputs according to their area allocation to crop and balance amount of fertilizer they use. This is the payment over the government pre-declared administrative price to the existing market price.

The best fertilizer management practice is a labor intensive technique which required extra human resources and motivation about the side effect of agro-chemicals. For popularizing the technique of nitrogen emission reduction from agriculture there should be incentive and certification of environmental friendly practice. If they economizing the nitrogen use for crop growing his compensation payment will be high in this regard. For extensive user or wasteful user will disqualify for having compensation payment.

Some regulative measures will be helpful for system operation like identification nitrogen vulnerable area where incidence of sea or normal flooding is high. The urea application restriction in flooding season could be good administrative policy.

It is proved that urea application in Bangladesh is over optimal or some time it cross the technical efficiency limit. With the guild line of fertilizer balance dozes a regulation of ceiling per hectare per year urea application should be fixed according to agro-ecological zone.

Finally, all suggested instruments well work effectively and efficiently when a comprehensive extension service work whole over the nitrogen vulnerable zone. Continues research and extension funding will significantly reduce the nitrogen emission from agriculture.

4. Conclusion

The nitrogen emission from agriculture through volatilization of NH3 and N_2O to atmosphere and leaching of NO_3 to surface and ground water are related to the amount of N within the system and to N surplus. In efficient management of fertilization are in soil have substantially complicated effect on earth system. The subsidized fertilizer leads this inefficiency in nutrient management in soil. From 1960 Bangladesh implemented food self-sufficiency policy at the cost of revenue pressure and other policy conflict. But still it is going on for economic and political back ground. After 1992 when an environmental policy significantly appeared, the instrument of fertilizer subsidy went through a critical evaluation. Considering the climate change and global warming sustainable management is now national as well international priority. Any how the country should reduce N emission from agriculture. The first and foremost steps to do this are withdrawal of urea subsidy and ensure best fertilizer management practice.

The subsidy withdrawal policy will helps to reduce wasteful use of resources as the raw material of the urea are natural gas and improve environmental quality of agricultural land, surface and underground water from nitrogen leaching problem. When price of a inputs are competitive the use of the inputs should at least optimum or economize.

The abolishment of the fertilizer subsidy will create some problem of self-sufficiency goal but in long run the benefit of good soil health helps to sustain production. The policy mix of economic, regulatory and knowledge base development will help to target oriented incentive to food policy and environmental policy for poverty reduction.

The most of policy study relating to fertilizer subsidy withdrawal is always starting with good economics rationality of efficiency ground. But at the end they are try to have conclusion on the favor of subsidy that mentioning the distributional aspect of humanitarian ground of subsistence farming survival issue. Some time inconclusive to the decision of sustain environment and food security or some sort of compromise with nitrogen emission. The well co-ordinate combination of policy instruments mention in the paper should carefully implement.

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Preparation and preparation and characterization of dimensionally stable anode for degradation of chlorpyrifos in water

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Abstract:

Chlorpyrifos (CP) is one of the most widely used organophosphate pesticides in agricultural pest control and in households as a termiticide. Treating chlorpyrifos-contaminated water is of very high importance because its excessive exposure may affect the central nervous system, cardiovascular system and respiratory system in humans. This research, therefore, addresses electrochemical degradation of chlorpyrifos by developing the anode material. Among the possible electrode materials, a dimensionally stable anode (DSA) was developed in order to mineralize chlorpyrifos in chloride free environment. The efficiency in degradation and electrochemical properties of the Ti/IrO_2 anode was investigated. The chemical oxygen demand (COD) results showed that COD removal efficiency of prepared Ti/ IrO_2 electrode was 65.1% in sulfate medium and 58.7 % in carbonate medium after the electrolysis time of 6 hours. Further, the study confirmed that OH^0 radical is generated in Na_2SO_4 electrolyte and the generated radical is scavenged by Na_2CO_3 reducing the removal efficiency. It was confirmed that the hydroxyl radical is the responsible factor during the electrolysis in chloride free environment. Finally, cyclic voltammetry (CV) diagrams show a considerable difference in electrochemically active surface area between the Ti/IrO_2 anode and uncoated electrode. It was found that the anodic charge increased from 29.8 mC to 149.67 mC after the development of anode. The stability was also investigated by accelerated life time test.

Key words:

Chlorpyrifos, Electrochemical degradation, Dimensionally stable anode, Chloride free environment, Accelerated life time test

1. Introduction

Organophosphorous pesticides have been widely used in agriculture, replacing organochlorine pesticides, especially due to their higher toxicity, higher decomposition rate and lower accumulation in the environment (Wu and Linden, 2010). Among them, chlorpyrifos (*0,0-diethyl-0-(3,5,6-trichloro-2-pyridinyl) phosphorothioate*), (CP) is one of the most extensively used organophosphate pesticides in the world, in agricultural pest control and in households as an insecticide. The usage of chlorpyrifos is rapidly increasing in the world, owing to the broad spectrum effectiveness, flexibility for use in multiple delivery systems, and relatively short persistence. Therefore, it causes for huge contamination of surface and drinking water, leading to damage to non target organisms like humans. Furthermore, it should be noted that excessive exposure to chlorpyrifos may cause poisoning, affect the central nervous system, endocrine system, immune system, reproductive system, cardiovascular system and respiratory system (Tang *et al*., 2011, Chen *et al*., 2012). As a consequence, United States (U.S.) and some European countries have been vastly restricted the use of chlorpyrifos. However, it is now one of the top commercial insecticides in Sri Lanka. As such, the greater attention should be paid to treat chlorpyrifos-contaminated water.

Several technologies such as ultrasonic and ozone treatments (Pengphol et al., 2012, Zhang et al., 2010; Zhang et al., 2011), photo-Fenton oxidation (Murillo et al., 2010), photo catalytic degradation using doped polycrystalline TiO_2 (Devi et al., 2009), high-pressure arc discharge plasma process (Meiqiang et al., 2006), ionizing radiation (Mori et al., 2006) electro-enzymatic degradation (Tang et al., 2011) and microbial degradation (Mallick et al; 1999) have been researched to remove chlorpyrifos from water. The electrochemical degradation of organic compounds has been investigated as an efficient and versatile technology due to factors such as in-situ chemical generation, ease in process control, environmental compatibility, safety, cost effectiveness and high efficiency (Fockedey and Lierde, 2002; Li et al., 2005; Martínez-Huitle and Andrade, 2011).

The preparation of dimensionally stable anodes (DSAs) with low cost, long life time, and high oxygen evolution potential have been directed towards a greater attention in past few years. The degradation efficiency with better properties highly depends on the anode material (Chen, 2004; Comninellis, 1994; Li et al., 2005; Martínez-Huitle and Andrade, 2011; Song et al., 2010; Zheng et al., 2011; Zhu et al., 2010). Several previous studies have been reported that the use of DSA with different anode materials for the electrochemical oxidation of different aromatic compounds (Canizares et al., 2005; Fockedey and Llierde, 2002; Feng et al., 2003; Radjenovic et al., 2011; Samet et al., 2010; Nava et al., 2008). In general, the deposition of metal oxides on titanium substrate is commonly used technique in the preparation of DSAs (Comninellis, 1994; Devilliers and Mahe, 2010). Moreover, the Ti/RuO_2 and Ti/IrO_2 anode materials are well known DSAs in the commercial industry. By comparison, RuO_2 has higher catalytic activity than IrO_2. In contrast, IrO_2 coated electrodes are more stable and have longer life time (Kim et al., 2002). Despite the cost of Ir chloride salt and Ti substrate is much higher, this type of electrodes are concerned for more applications in recent published works. Because it was found that aromatic compounds were almost completely oxidize into intermediate products or promote total oxidation to CO_2, H_2O and SO_2 (Chatzisymeon et al., 2010).

Among primary oxidant species involved for the reaction, especially hydroxyl radicals (OH^0) are generated, when electrochemical degradation is carried out in chloride free environment. The production of OH^0 radicals are based on water splitting. The OH^0 radicals can be classified as the second strongest oxidant species (E° ($HO°/H_2O$) 2.8 V/RHE), while fluorine (E° (F_2/HF_{aq}) 3.03 V/RHE) takes the first place (Samet et al., 2010). This study therefore, addresses electrochemical degradation of chlorpyrifos by developing the IrO_2 type DSA in chlorine free environment. Although the electrochemical degradation of chlorpyrifos has given considerable attention (Samet et al., 2010), the use of DSA like Ti/IrO_2 for that has never attempted before. The major objectives of this study are to investigate the efficiency in degradation and electrochemical properties of this developed anode.

2. Experimental

2.1 Materials

Chlorpyrifos (99.5%, Sigma-Aldrich), $IrCl_3.3H_2O$ (Ir -53-56 %, ACRDS Organics), ethanol (99% AR, Fisher Scientifics), Na_2SO_4 anhydrous AR (99% ,SDFCL), NaOH (97.5 %, BDH), Na_2CO_3 (99% ,BDH) , RNO (Sigma-Aldrich), $H_2C_2O_4.2H_2O$ (99%, LOBAL Chemie), HCl (37%, BDH), $K_2Cr_2O_7$(99%, Avondale Laboratories), H_2SO_4(98%, Fisher Scientifics), Ag_2SO_4 (Fisher Scientifics), were all of analytical reagent grade. All aqueous solutions were prepared by using deionized (DI) water. The structure of the pesticide is shown in Figure 01.

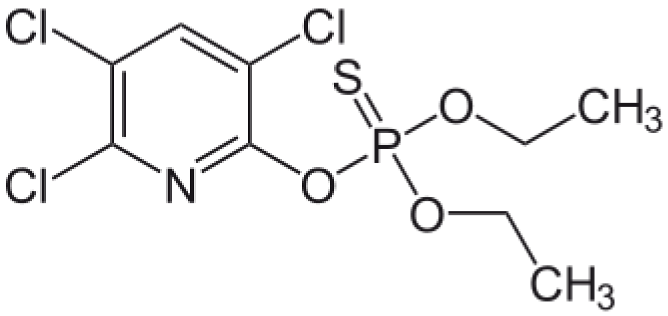

Figure 01: Structure of Chlorpyrifos.

2.2 DSA preparation

Pretreatment of titanium substrate (10 mm x 10 mm x 2.5 mm i.e., an effective geometric area of 2.5 cm^2) were carried out before dip coating, to ensure good adhesive properties. The substrate was first sandblasted and pretreated using 5% (w/w) oxalic acid solution for 10 min and 37% (w/w) HCl acid for 5 min, respectively. Then it was dried at 100 ^{0}C. The precursor solution for depositing IrO_2 was prepared by dissolving 0.56g of $IrCl_3.3H_2O$ in 4.6 ml ethanol, air dried in 80 ^{0}C for 5 min to allow solvents to vaporize, and then calcinated in an oven at 450 ^{0}C for 10 min. This process was repeated until final coating load of 1mg/cm^2. Finally it was post backed at 500 ^{0}C in muffle furnace for 1 h (Fockedey and Lierde, 2002).

2.3 Determination of Chemical oxygen demand

The chemical oxygen demand (COD) for the degradation of chlorpyrifos was conducted according to the standard potassium dichromate method (Clesceri et al., 1998). The Ti/ IrO_2electrode described above as an anode and a Ti plate as a cathode was set at distance of 1.0 cm. The operating current density was 20 $mAcm^{-2}$. The appropriate amount of samples was collected during 6 hours and absorbance was measured by using UV-visible (Shimadzu, UV- 2450, wavelength=600.0 Å) spectrophotometer.

2.4 Determination of current efficiency

Based on the measured COD values, the instantaneous current efficiency (ICE) during electrolysis was calculated as follows (Sun *et al*., 2012).

$$ICE = \frac{[(COD)_t - (COD)_{t+\Delta t}]FV}{8I\Delta t} \qquad (1)$$

where $(COD)_t$ and$(COD)_{t+\Delta t}$are the initial chemical oxygen demand ($gO_2\ m^{-3}$) at time t and t+Δt (s) respectively. I is the applied current (A), F is the Faraday constant ($Cmol^{-1}$) and V is the volume of the electrolyte (m^3).

2.5 Qualitative analysis of free radicals

The production of free radicals during electrolysis was analyzed using Na_2SO_4 solution containing p-nitrosodimethylaniline (RNO). Ti/ IrO_2 electrode was used as the anode and a Ti plate was used as the cathode. Distance between the anode and the cathode was 1.0 cm. The operating current density was 20 $mAcm^{-2}$. The bleaching of RNO in supporting electrolyte Na_2SO_4 by hydroxyl radicals was measured by absorbance changes of samples taken at time intervals of 5 or 10 min by UV-visible spectrophotometer (Shimadzu, UV- 2450) at 440 nm (Li et al, 2009).

2.6 Cyclic Voltammetry

In order to investigate the behavior of Ti/ IrO_2 electrode, cyclic voltammetry (CV) was carried out in a three electrode cell using potentiostat galvanostat equipment (Autolab, PGSTAT128N). The electrode under study was used as the working electrode (WE), titanium plate as the counter electrode (CE), and Ag/AgCl electrode was used as the reference electrode (RE). The 0.5M Na_2SO_4 was used as the electrolyte. Range of voltage scan was from -2.5 to 2.5 V at the scan rate of 0.1 V/s.

2.7 Stability of Ti/ IrO_2 electrode

The accelerated life time tests were performed in order to assess the electrode stability in a three-electrode cell. The electrodes under study were used as the working electrode (WE), titanium plate as the counter electrode (CE), and Ag/AgCl electrode was used as the reference electrode (RE). The electrolyte was 0.5 M H_2SO_4. An anodic current density of 800 mA/cm^2 was used in all the investigations. Experiments were carried out in the room temperature (25^{0}C). The electrolysis time at which the anodic potential reached 2V higher than the voltage at time zero was considered as the lifetime of the coated anode. Triplicate samples of the electrodes were tested in all experiments.

3. Results and discussion

3.1 Degradation efficiency

One of the ways of estimating the degradation efficiency is studying the COD removal during the electrolysis. In our study, the electrochemical oxidation of chlorpyrifos was carried out with two electrolytes. Na_2CO_3 was used as OH^0 radical scavenger (Wu et al., 2007). According to Figure 02, it was found that prepared Ti/ IrO_2electrode could mineralize chlorpyrifos up to 65.1% in Na_2SO_4 and 58.7 % in Na_2CO_3 after the electrolysis time of 6 hours. COD concentration was also reduced from 183.16 mg/L to 64.28 mg/L in Na_2SO_4 and from134.36 mg/L to 54.60 mg/L in Na_2CO_3. Consequently, it is clear that OH^0 radical is generated in Na_2SO_4 electrolyte and the generated radical is scavenged by Na_2CO_3, reducing the removal efficiency.

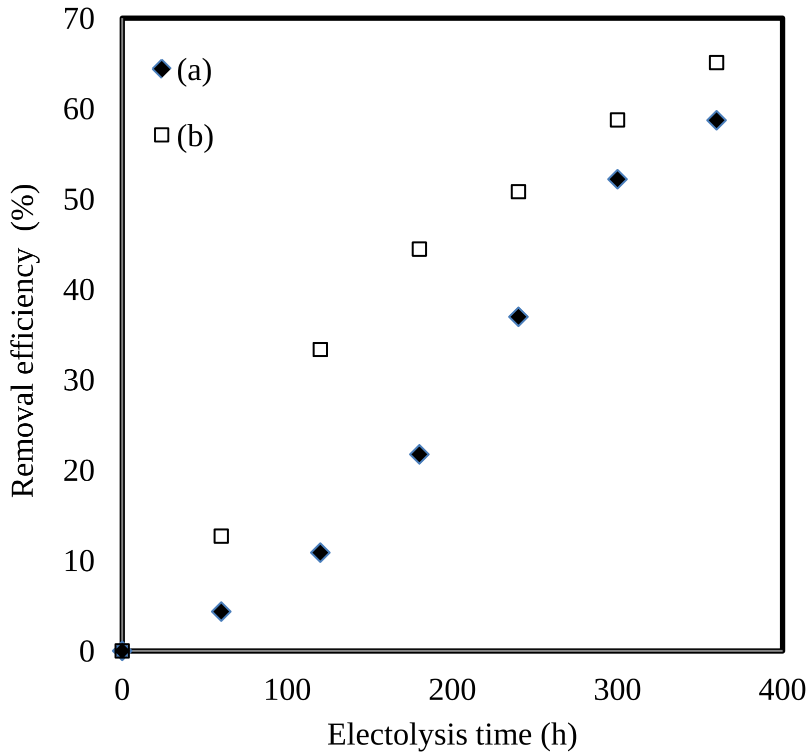

Figure 02: (a) Variation of COD removal percentage with electrolysis time of Ti/IrO_2 anode in Na_2SO_4 electrolyte. (b) Variation of COD removal percentage with electrolysis time of Ti/IrO_2 anode in Na_2CO_3 electrolyte. Current density = 20 mA/cm^2, Reaction time = 6h, [CP] = 1 mg/L and temperature = 25^0C

3.2 Instantaneous Current efficiency

Figure 03 shows the instantaneous current efficiency (ICE) during electrochemical degradation of chlorpyrifos. It is clearly seen that, the value of ICE was relatively high in the initial period of reaction, and then decreases dramatically with the increase of electrolysis time. The ICE is 0.5 during the first two hours, where a high ICE value is observed. This feature is characteristic due to better mass transfer at higher initial COD concentration (Polcaro et al., 1999). Moreover, higher activity and stability of the anode during initial reaction hours may have contributed to this result.

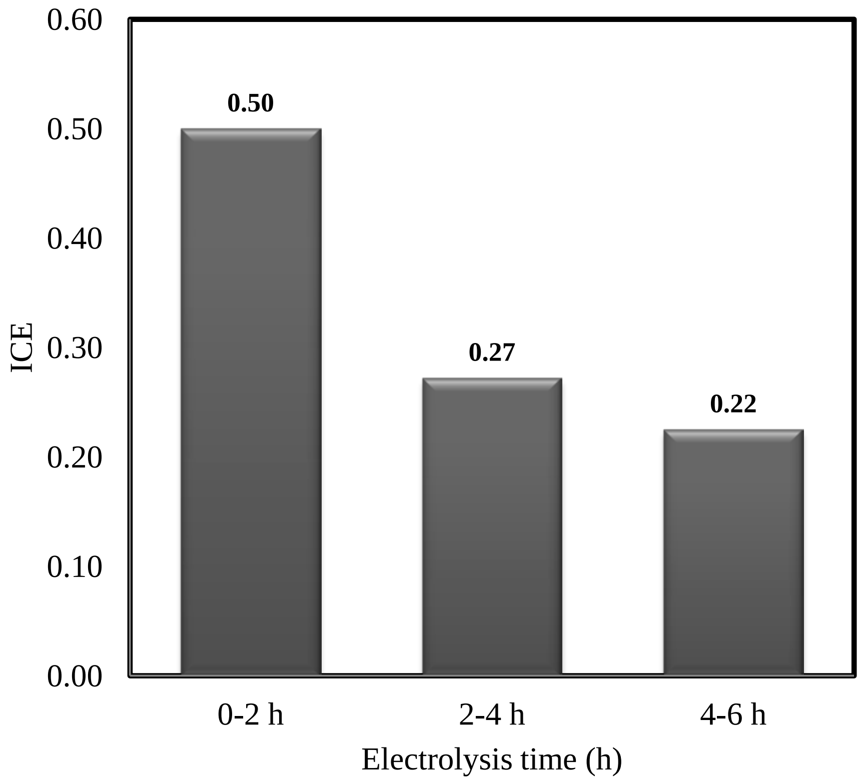

Figure 03: Change in ICE with respect to electrolysis time of Ti/IrO_2 anode for the degradation of 1 mg/L chlorpyrifos solution. Electrolyte= 10 g/L of Na_2SO_4, Current density = 20 mA/cm^2, Reaction time = 6h

3.3 Determination of OH^0 radicals production

In an attempt to identify the production of OH^0 radicals during the electrochemical treatment, a test was carried out using the bleaching of RNO. RNO is capable to identify OH^0 radicals due to selective reaction with OH^0 radicals (Comninellis, 1994). Figure 04 shows that the absorbance of RNO decreased rapidly in the initial 35 minutes of this anode. The bleaching ratio of RNO at Ti/ IrO_2 anode was 87.3%, indicating that the rate of bleaching of RNO on this anode is high. It is suggested that the OH^0 radical is produced at Ti/ IrO_2 anode and then bleaching was successfully occurred. Therefore, this fact complies that OH^0 radical is responsible in degrading chlorpyrifos in chloride free environment.

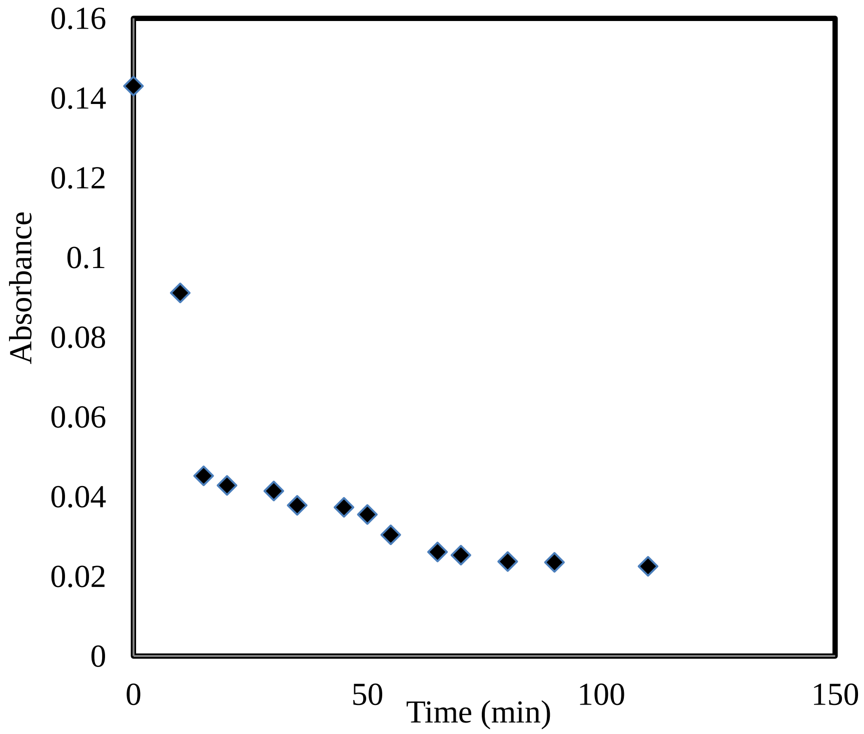

Figure 04: The electrochemical bleaching of RNO in Na_2SO_4 of Ti/IrO_2 anode. Current density = 20 mA/cm, Reaction time = 110 min, pH = 6.14.

3.4 CV measurements

The cyclic voltammograms were taken for the Ti/IrO_2 anode and uncoated electrode. It shows a considerable difference in electrochemically active surface area in Figure 05. According to the CV diagrams, it was found that the anodic charge increased from 29.8 mC to 149.67 mC after the development of Ti/IrO_2 anode. This finding further confirms the increment in electrochemically active surface area because of the coating layer applied on the substrate. Such increment is important to generate a greater amount of OH^0 radicals.

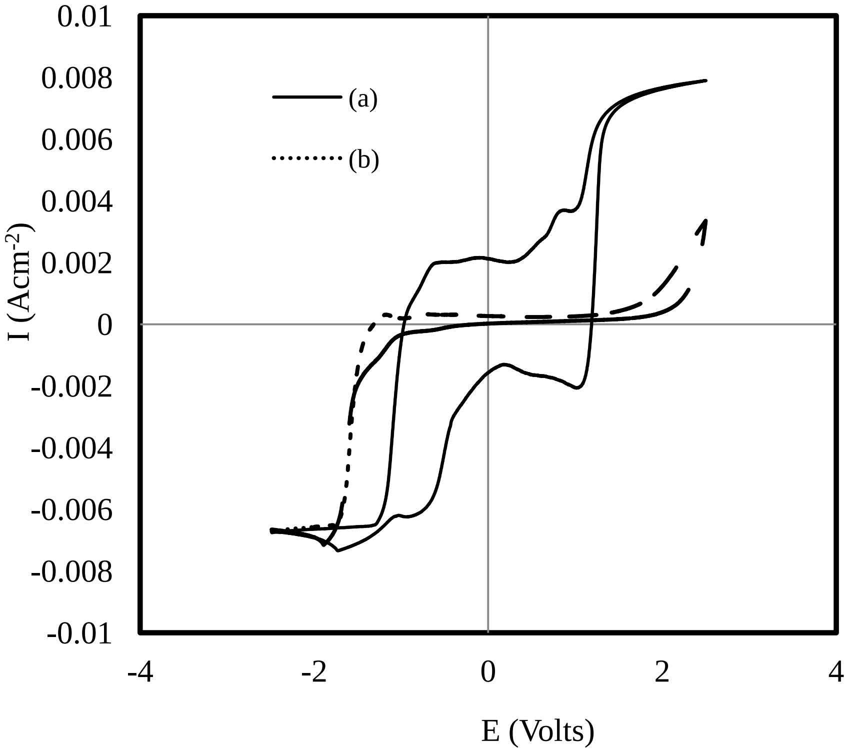

Figure 05: Cyclic voltammograms of (a) Ti/IrO_2 anode (b) Ti substrate. Scan range = 2.5 V to -2.5 V, Scan rate = 0.1 V, Electrolyte = 0.5M of Na_2SO_4, Geometrical area of electrode = 2.6 cm^2, Reference electrode = Ag/AgCl.

3.5 Accelerated life time test

The accelerated life time test was operated at a current density of 800 $mAcm^{-2}$ in 0.5M of H_2SO_4 solution, used to evaluate long term electrochemical stability of the coating of Ti/ IrO_2 anode. The life time of this experiment is determined as the time taken for the voltage measured increases for 2V during the test. The Figure 06 shows that the accelerated life time of the Ti/IrO_2 anode is 7840 s (approximately 2 h). A long life time suggests a good stability.

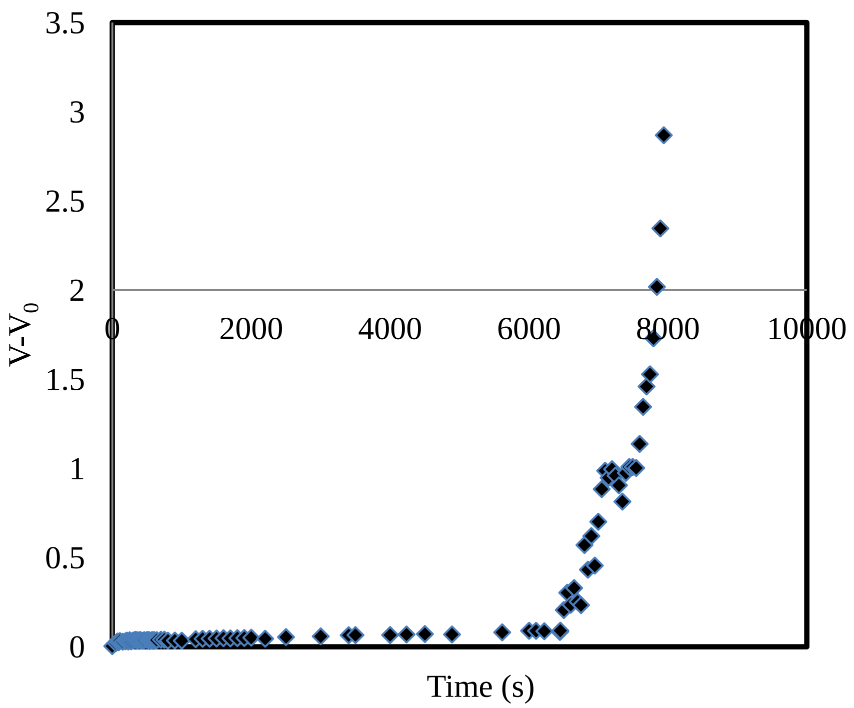

Figure 06: Accelerated life time of Ti/IrO_2 anode. Electrolyte = 0.5M of Na_2SO_4, Current density = 800 mAcm , Reference electrode = Ag/AgCl.

4. Conclusions

In this work, Ti/ IrO_2 anode was developed in order to anodic oxidation of chlorpyrifos in chloride free environment and its electrochemical properties were investigated. The main conclusions can be summarized as follows.

- The COD removal efficiency of Ti/ IrO_2 electrode was 65.1% of after the electrolysis time of 6 hours.
- ICE value is relatively high in the initial period of reaction, and then decreases dramatically with the increase of electrolysis time.
- It confirms that the hydroxyl radical is the responsible factor during the electrolysis in chloride free environment, using RNO and radical scavenging effect.
- CV diagrams show that the anodic charge increased from 29.8 mC to 153.76 mC of Ti/IrO_2 anode.
- The life time of Ti/IrO_2 anode is 7840 s (approximately131 min/ 2 h).

Results conclude that the Ti/ IrO_2 electrode is a better anode to degrade chlorpyrifos in chloride free environment. Indeed, surface coating affects the oxidant generation. However, further study should be conducted to improve the stability of this anode by adding secondary oxide.

5. Acknowledgement

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Spatial distribution of total hardness and electrical conductivity in Tehran city groundwater

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Abstract

Industrial development accompanied by population and consumption growth has imposed heavy pollution loads to natural resources. Water resource contamination is one of the major challenges in the way of sustainable development. From the total accessible fresh water all around the world more than 90% is contributed to groundwater resources. Accordingly, sophisticated attention towards monitoring the quality and quantity of such resources would play a key role in achieving the global sustainable development in near future. Hydrochemical quality of groundwater with a special focus on EC and TH in an aquifer in capital of Iran was analyzed in this study. Tehran is among the first twenty over populated capitals all around the world and accordingly regional groundwater quality degradation has been a potential threat during recent years. In order to appropriately cover the whole city, 34 boreholes were considered for sampling the groundwater. Electrical conductivity was measured at the sampling points by a digital EC meter. Ca and Mg concentration were measured by flame photometry and flame atomic absorption spectrometer (FAAS), respectively. The spatial distribution of EC and TH obeys an increasing pattern south-eastwards which is coincided with the pattern of urban elevation decrease. Besides such geopogenic reason, the dense agricultural land use as well as the higher per-capita green space in southern areas may be addressed as an anthropogenic source of contamination. Excessive irrigation and evapo-transpiration, leaching of fertilizers and soil conditioners have a considerable potential to deteriorate the groundwater quality.

Keywords: Tehran, groundwater, electrical conductivity, total hardness

1. Introduction

The importance of groundwater as an alternative water supply is increasingly recognized, in response to escalating costs and decreasing quality of surface waters [1- 9].

Tehran city is located between the latitudes of 35o and 36o north and the longitudes of 50^o and 53^o east. The location of Tehran city in Iran as well as the arrangement of its 22 districts is shown in Figure 1. Occupying 665.3 square kilometers (around .4 percent of Iran's total area), this city has a population of about 7,700,000 people (more than 11 percent of Iran's total population). A remarkable growth rate in population of this city is observed during recent decades (Figure 2).

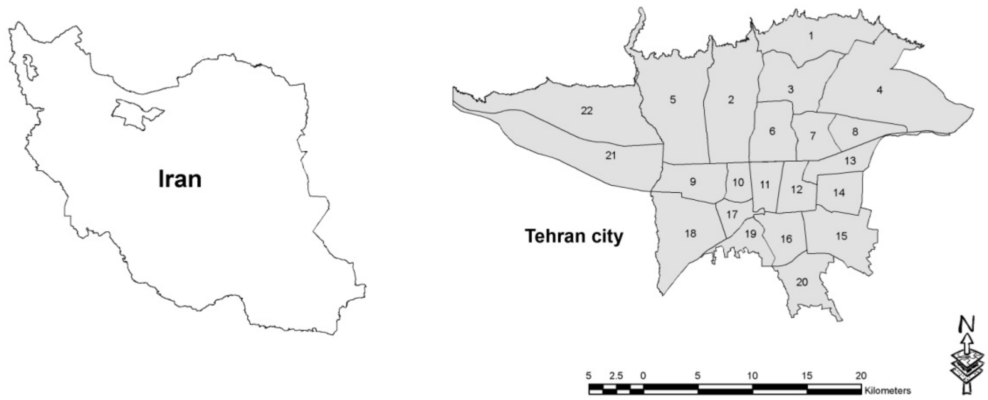

Fig. 1: The layout of Tehran city and its districts

Table 1: Number and amount of water discharge from deep wells in Tehran within recent decades

Date	Water discharge (million m^3/year)	No. of wells
1968	638.8	3906
2009	901.4	26076

2. Methods

In order to appropriately cover the area 34 boreholes were considered for sampling the groundwater. Parameters like electrical conductivity and total hardness (Ca and Mg) were taken in to consideration. Electrical conductivity (EC) of each water sample was measured at the sampling points by a digital EC meter. In laboratory the duplicate aqueous samples of about 1000 ml of each batch collected from 20 sampling sites, were filtered through polycarbonate filter (0.45 mm pore size) and treated with 2 ml of concentrated HNO3 for metal analysis. The acid-treated water samples were analyzed for determination of Ca and Mg by further 20-time dilution with ultra pure water, and were measured by flame photometry and flame atomic absorption spectrometer (FAAS), respectively. For statistical analysis software like Surfer and Excel were used through data processing.

3. Results and discussion

The spatial distribution pattern of electrical conductivity and total hardness in groundwater of Tehran city is illustrated in Figs. 2 and 3. As it is indicated in Figures 2a and 2b an increasing pattern is observed within the northwest- southeast diagonal direction.

Green spaces as well as population of each district were also taken into consideration. As it is illustrated in Figure 3 the central and southern districts show more per-capita green space values in comparison with northern ones.

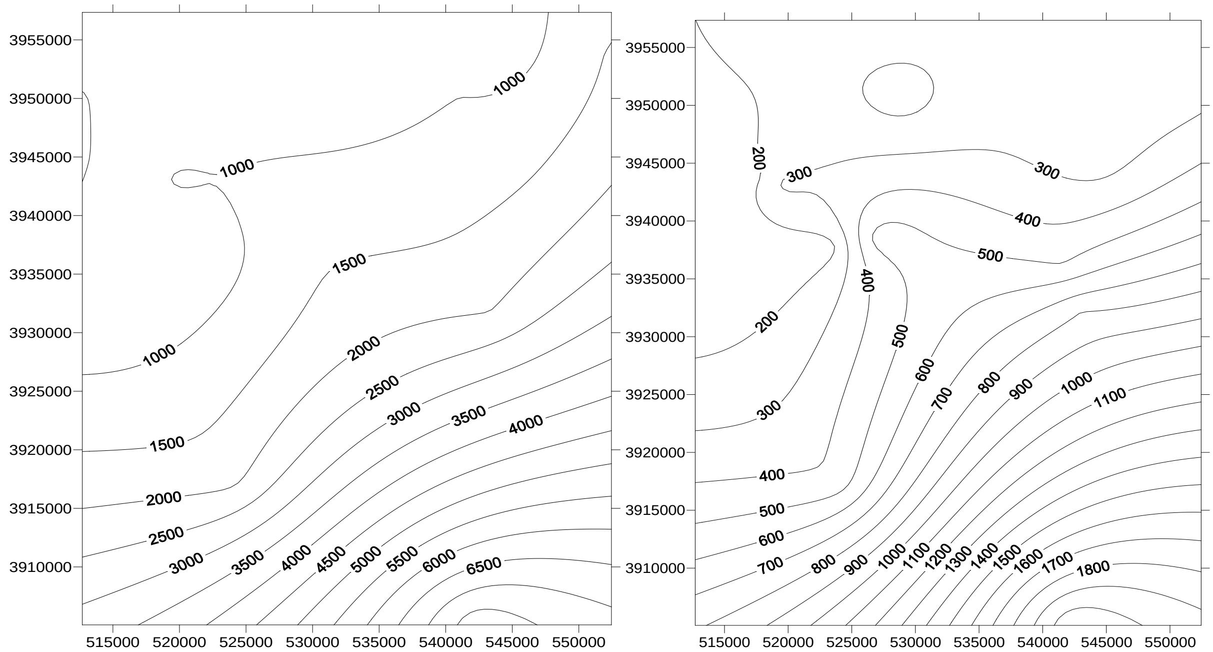

Fig. 2a: Spatial distribution of EC values in Tehran city groundwater, 2b: Spatial distribution of TH values in Tehran city groundwater

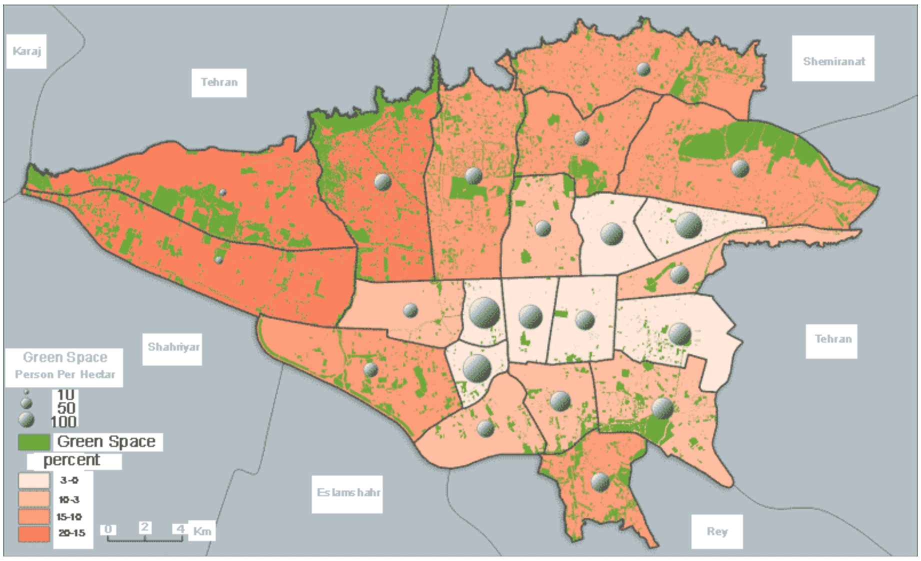

Fig. 4: Per capita green space within Tehran city

4. Conclusions

Hydrochemical quality of groundwater with a special focus on EC and TH in an aquifer in capital of Iran was analyzed in this study. The spatial distribution of EC and TH obeys an increasing pattern south-eastwards. Alongside the mentioned direction the city elevation also decreases. Furthermore, central and southern districts involve more pre-capita green space values. Such situation indicates more irrigation and consequently more groundwater infiltration potential. Additionally, the natural elevation change pattern of the city and general groundwater flow direction also justify the higher EC and TH values in southern and southeastern areas. Another reason that justifies the higher concentration in mentioned areas may be attributed to dense agricultural land use in southern Tehran. Besides excessive irrigation and evapo-transpiration, leaching of fertilizers and soil conditioners adversely affect the groundwater quality. Uncontrolled groundwater pumping mainly for regional drinking and agricultural use during recent years has deteriorated the groundwater quality especially in southern parts.

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Sustainable Energy Consumption in Developing Countries: An Analysis on Thailand's Household Socio-Economic Survey

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Abstract

Developing countries have been dramatically changing their ways of consuming energy for the past decades. Between 1987 and 2006, developing countries experienced high rate of growth in energy consumption as much as 63 percent per year while energy consumption in OECD countries grew only around 1.5 percent per year. Without effective policies, such dramatic change in energy consumption would undoubtedly lead to unsustainable future of global energy. Focusing on household's behavior towards energy consumption is of importance in implementing energy policies in developing countries. To conduct such research requires accurate and well-organized data such as household socio-economic survey. Thai household socio-economic survey significantly shows variation of energy consumption across income classes, which is one of the main characteristics of developing countries.

Keywords: "sustainable energy consumption", "household socio-economic survey", "income quintiles", "energy policy"

1. Introduction

Energy policy in developing countries has been a controversial debate among environmentalists for several years. Panel studies of Lee (2005) and Sari et al. (2007) show that energy consumption statistically determines economic growth in developing countries but not vice versa, which implies that energy conservation policy might hamper economic growth in the long-run. However, such macro-level study on energy policy is still unable to answer the question of how energy policy of developing countries should be designed in order to maintain desirable growth. Analysis in micro level which captures individual behaviors in society should also be considered. Pachauri (2002) utilizes input-output table and household data, and finds that as income of the country rises, Indian households tend to consume more gas and petroleum products and less traditional energy like kerosene.

High inequality among income class is also one of the main characteristics of developing countries、which should be taken into account when conducting energy policy in developing countries. For example, Thailand's household socio-economic survey significantly shows some variation of energy consumption among five income classes. While the lowest income quintile consumes less than five percent of total energy consumption, energy consumption of the highest income quintile accounts for over 50 percent. Such information should be useful for designing their sustainable energy policy in developing countries.

Consequently, this motivated the current study to conduct analysis on Thailand's household energy consumption as a case study to seek for sustainable energy policy in developing countries.

2. Objective

The aim of our paper is to: 1) statistically analyze energy consumption pattern by income class, using Thailand's household economic survey in 2006, 2007, 2008, and 2009. To discuss in detail, this paper divides household income distribution into ten income quintiles, and investigates energy consumption pattern of each income quintile by different types of energy; 2) clarify how consumption pattern of each energy and each income class affects carbon emission over time; 3) conduct various policy scenarios to estimate household's energy consumption as well as carbon emission; and finally 4) discuss some implications on energy policy implementations in developing countries based on fact findings.

3. Method

The study first divides household population into 10 quintiles. The first quintile shows cumulative income occupied by 10 percent of the lowest income households while the tenth quintile shows cumulative income occupied by 10 percent of the highest income households.

The study then clarifies energy consumption pattern of each income quintile by energy source from 2006-2009. Thus, energy consumption in monetary unit (Baht) is converted to physical unit by using Thailand's energy price index. Net calorific values provided by Ministry of Energy of Thailand are also referred in converting physical unit into calorific value.

For instance, to obtain electricity consumption in kilowatt per hour, electricity consumption in monetary unit (Baht) is divided by electricity price per kilowatt per hour. Next, the physical value of kWh is converted into MJ by referring to net calorific energy value, which is provided by Ministry of Energy of Thailand.

Carbon dioxide emissions are then estimated by using carbon emission factors provided by IPCC and Ministry of Energy of Thailand except for the case of electricity since proportion of electric generation fuels are expected to be different from OECD countries.

Finally, two scenarios of energy policies are simulated.

The first scenario assumes a change in carbon emission factor of electricity with 10 percent increase in natural gas power plants and 10 percent decrease in coal and lignite power plants, implying a change in technology of power genration in the long run. While natural gas accounts for over 60 percent of domestic energy production in Thailand, coal and lignite accounts for only 11 percent. In addition, over 70 percent of electricity are generated by natural gas, and 29 percent by coal and lignite. Therefore, there is potential that Thailand utilizes more natural gas and less lignite and coal for power generation. The emission factor in this scenario accounts for 0.2698.

Scenario 2 assumes the government of Thailand imposes 5% of price tax on electricity and diesel consumptions, which is directly incorporated to the nominal price of energy. In order to find response of households to the change in price according to tax, the study uses energy price elasticity of -0.1845 obtained by Dr. Kraipornsak (2006).

4. Data

The data mainly used in this analysis is Thailand's Household Socio-Economic Survey constructed by the National Statistics Office of Thailand, spanning from the period 2006-2009. Expenditures, incomes and other social features of around 140,000 households are observed by the National Statistics Office annually.

In order to clarify energy consumption pattern of Thai households, various sources of energy, which are electricity, cooking gas, gas for other purposes than cooking, charcoal and wood, kerosene, gasoline 91, gasoline 95, high-speed (HS) diesel as well as water supply and underground water are analyzed,

Energy price index in unit Baht and energy calorific values are also referred to convert expenditure in monetary unit into physical and calorific unit,

Finally, the study estimates carbon emissions of various energy sources using carbon emission factors provided by IPCC Task Force on National Greenhouse Gas Inventories except for the case of electricity consumption. Since power generation fuels in Thailand are expected to be different from those of OECD countries, the study uses carbon emission factor for electricity provided by Hinchiranan, Department of Energy Policy and Planning (2006) to estimate carbon emission by electricity consumption in Thailand. The carbon emission factor is equal to 0.5057, which is different from 0.42-0.5 of OECD countries.

5. Result

5.1 Energy Consumption Pattern among Income Classes

Figure (1) and (2) demonstrate energy consumption patterns among income classes by energy source in 2006 and 2009 respectively. During 2006-2009, significant changes are not observed. Therefore, we skip the results of year 2007 and 2008. During the period, there are high inequalities among income classes for electricity, cooking gas consumption, water, and transport fuel consumptions. Energy inequality slightly improved only in electricity and kerosene consumption. However, for other energy sources, such improving trends are not found.

In 2006, the highest income households consume as much as 57% of total electricity consumption, which is 10 times higher than the lowest income household. For all transportation fuel, the highest income consumed 7 times higher amount of transport fuel than the lowest income.

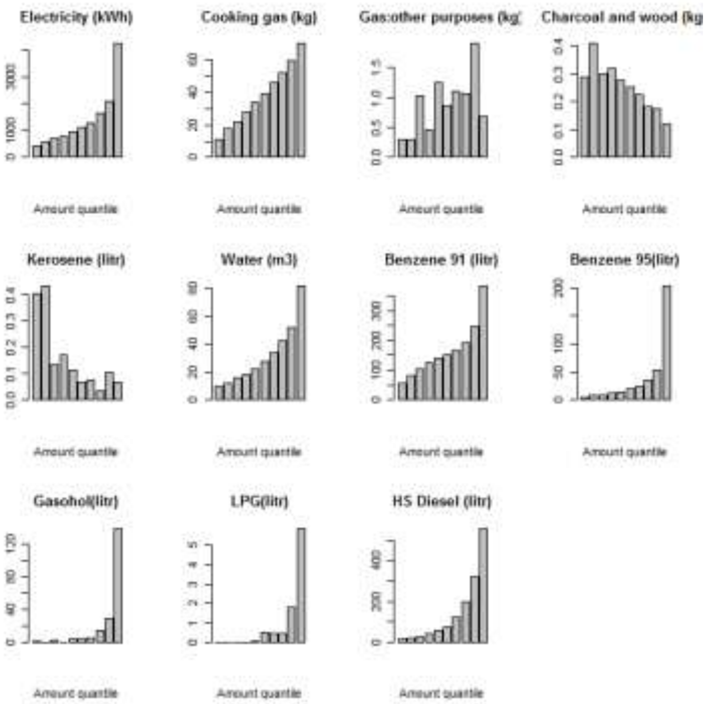

Figure 1: Energy Consumption by Income Class and by Energy Source in 2006

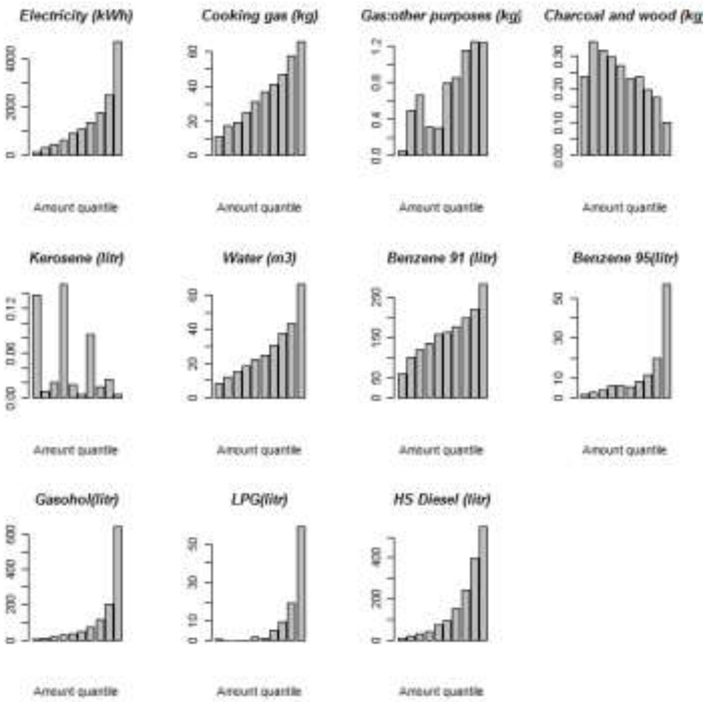

Figure 2: Energy Consumption by Income Class and by Energy Source in 2009

This can be implied that there is high degree of progressive energy inequality among income groups especially for electricity and transportation fuels. In contrast, inverse inequality for charcoal and kerosene consumption are observed in this study, suggesting that charcoal and kerosene are inferior energy for Thai households.

5.2 Carbon Emission

Figure (3) and Figure (4) show carbon emission by income class in 2006 and 2009 respectively. Due to zero value of charcoal carbon emission factor and insufficient data, only 7 energy sources can be estimated for carbon emission. During 2006-2009, total household carbon emission increased by 19 %, from 13,069 kg-COE to 15,545 kg-COE per household per year.

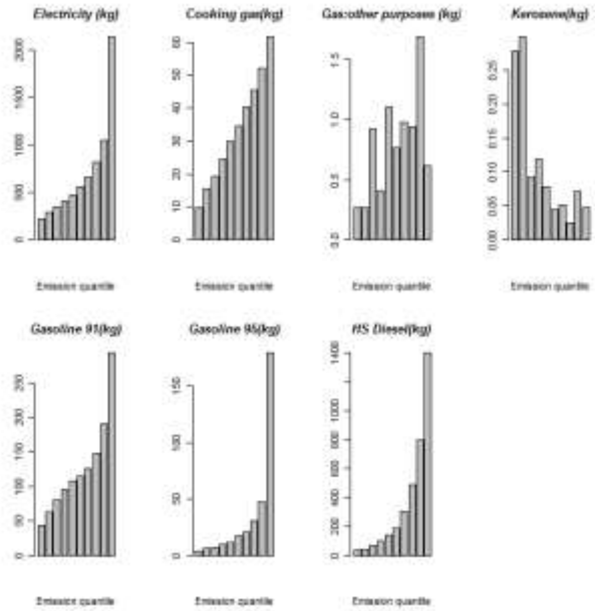

Figure 3: Carbon Emission by Income Class and by Energy Source in 2006

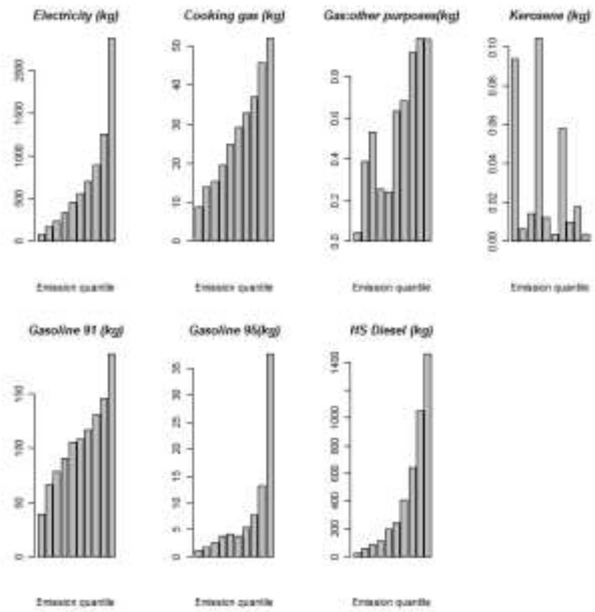

Figure 4: Carbon Emission by Income Class and by Energy Source in 2009

While carbon emission from electricity and HS diesel consumptions increased by 30% and 13% respectively, carbon emission from other energy consumptions decreased by average 3%. In addition, household electricity and high-speed diesel consumptions account for 60 % and 27% of total household carbon emission.

This implies that the two energies are the main factors for carbon emission in Thailand, and should be regulated in the long term in order to sustain economic and environment of the country.

5.2 Simulation

According to the result, the study simulates policy scenarios related to reduction in consumptions of electricity and high-speed diesel. The results of scenario 1 and scenario 2 are illustrated by Figure 5 and Figure 6 respectively. 10 percent increase in natural gas power plants and 10% reduction in coal power plant (scenario 1) results in 29% or 4,537 kg-CO2 decrease in carbon emission per household. This is directly obtained from 46% reduction in CO2 emission from electricity consumption. Additionally, 5% percent of electricity and high-speed diesel taxes (scenario 2) result in 22% and 58% reduction in CO2 emission respectively, which accounts for 28% or 4,598 in kg-CO2 decrease in total carbon emission per household.

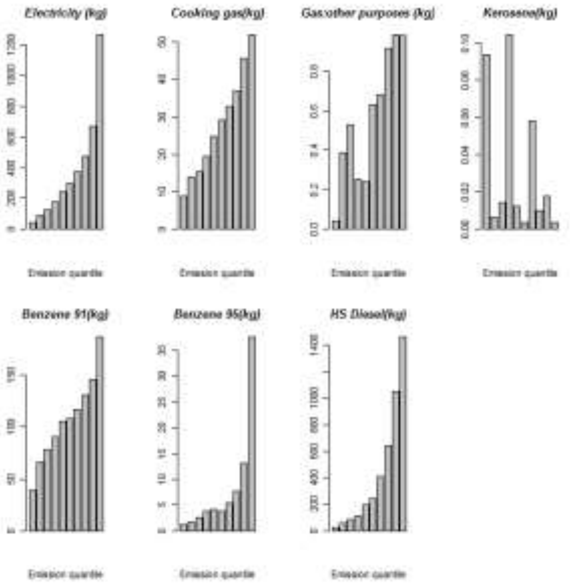

Figure 5: Change in Carbon Emission by Scenario 1 in 2009

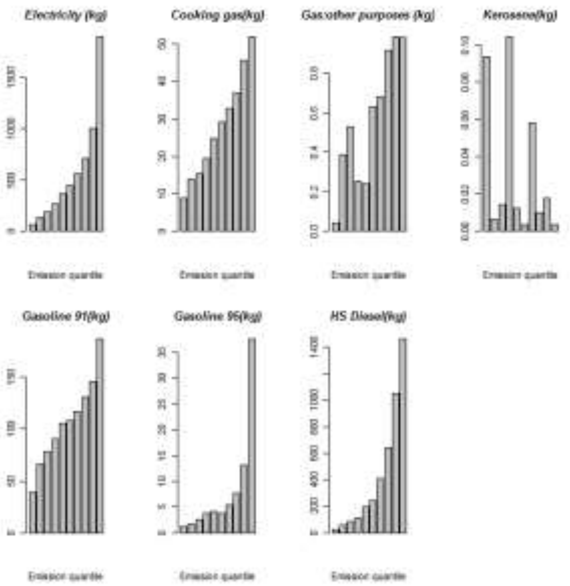

Figure 6: Change in Carbon Emission by Scenario 2 in 2009

6. Policy Implications

The simulation result implies that energy policies imposed on household electricity and diesel consumptions would result in carbon reduction in some level. Scenario 1 implies that adopting technology towards domestic and cleaner energy like natural gas would substantially reduce carbon emission in household sector. In scenario 2, it can be seen that electricity tax can also substantially reduce carbon emission in household sector.

However, since change in energy consumption of each income class is not assumed in the scenario analysis, energy policy imposed individually on each income quintile cannot be discussed in the current paper. Moreover, the effect of energy policy on economic growth should also be observed. Therefore, it is necessary to conduct more researches in order to find a more suitable and more sustainable energy policy.

7. Conclusion

The paper clarified energy consumption pattern by income class of Thai households by statistically analysing household socio-economic data of Thailand from the period 2006-2009. The paper found that there were high inequalities in energy consumption among household income classes especially for electricity consumption and transportation fuels. The highest income class was responsible for as much as 60 percent of total household energy consumption. The study also estimated carbon emission of each income class and found that the highest income group emitted carbon emission 7 times higher than the lowest income. Moreover, it can be seen that electricity consumption and diesel consumption of households were the main source of carbon emission. Therefore, the current study conducted policy scenarios based on the fact findings. The first scenarios assumed a change in carbon emission factor, which refers to the technology level of country. The result implied that adopting cleaner energy and technology on power generation could substantially decrease carbon emission of Thailand. For scenario 2, taxes on carbon-intensive energies such as electricity and high-speed diesel might also be an option to reduce carbon emission. However, the effects of such policies on economic growth should also be studies further in the future.

8. Acknowledgement

The authors would like to thank IPCC Task Force on National Greenhouse Gas Inventories, the National Statisitcs Office of Thailand, and the Energy Policy and Planning Office, Ministry of Energy of Thailand for data contributions.

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10. Biography

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After completing her undergraduate degree in Economics at Chulalongkorn University, Thailand, Saranyupa worked as a research trainee at the Ministry of Foreign Affairs of Thailand for one year, and afterwards received a scholarship from the government of Japan to continue her graduate studies in economics in Japan. Since she has a particular interest in environmental problems and sustainable development, she is currently undertaking her Ph.D. program in Environmental Economics, focusing her research on sustainable economic development and sustainable environmental policy in developing countries.

THE GROWING CHALLENGE OF E-WASTE IN INDIA AND PREVENTIVE MEASURES

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Abstract

Though the management of electronic waste in India has been a growing concern for the past decade, it is the solid waste and household trash that have received the most attention. Owing to the unique Indian scenario that comprises a large population with an increasingly disposable income, a tremendous amount of Waste Electronic and Electrical Equipment (WEEE) is being generated, which is primarily managed in a hazardous manner. To help address the woefully inadequate e-waste management infrastructure, the Government of India introduced *The Electronic Waste (Management and Handling) Rules, 2011*, which have been in effect since 1st May, 2012. This paper discusses the nature of e-waste, the health implications of its improper disposal and its specific scenario in India. Besides the aforementioned topics, the paper also delineates preventive measures to combat this growing menace.

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The Growing Challenge of E-Waste in India and Preventive Measures

1 Introduction

The electronic industry is the world's largest and fastest growing manufacturing industry. The consequence of its consumer oriented growth combined with rapid product obsolescence poses a new environmental challenge - the growing menace of "Electronics Waste" or "e waste". 'E-waste' is a collective name for discarded electronics devices that enter the waste stream from various sources. E-wastes contain over 1000 different substances, many of which are toxic and potentially hazardous to environment and human health if not handled in an environmentally sound manner that adheres to a stringent protocol.

2 What is E-Waste?

As defined by the Indian Government under The E-Waste (Management and Handling) Rules, 2011, E-Waste is any Waste Electrical and Electronic Equipment (WEEE), whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded.

The electrical and electronic equipment can be broadly categorized into the following categories:

- Large household appliances (refrigerator, freezer, washing machine, cooking appliances)
- Small household appliances (vacuum cleaners, watches, grinders, etc.)
- IT and Telecommunication equipment (PCs, printers, telephones, telephones, etc.)
- Consumer equipment (TV, radio, video camera, amplifiers, etc.)
- Lighting equipment (CFL, high intensity sodium lamp, etc.)
- Electrical and electronic tools (drills, saws, sewing machine, etc.)
- Toys, leisure, and sport equipment (computer/video games, electric trains, etc.)
- Medical devices (with the exception of all implanted and infected products, radiotherapy equipment, cardiology, dialysis, nuclear medicine, etc.)
- Monitoring and control instruments (smoke detector, heating regulators, thermostat
- Automatic dispensers (for hot drinks, money, hot and cold bottles, etc.)

Compiled From: The Environment Agency, UK - (www.environment-agency.gov.uk)[1]

This catalogue of new wastes poses a direct challenge, for its proper disposal or recycling in the present set up is technical and expensive. The issue has assumed serious global dimensions: e-waste creates serious problems for workers, the environment and communities.

[1] *The Environment Agency, UK - (www.environment-agency.gov.uk)*

The waste electrical or electronic equipment include all components, sub-assemblies, and consumables, which are either a part or whole of such products at the time of discarding. The various items found in E-waste in different ranges make E-waste more diverse and complex in nature *(UNEP-2007)*. However, it shows that E-waste from these items can be dismantled into relatively small number of common components for further treatment. *Table 1* shows the major components present in a select number of appliances.

Household Appliances	Refrigerator	Motor, cooling, plastic, insulation, glass, rubber, BFR plastic, incandescent lamp, batteries, CFC, HCFC, HFC, HC
	Washing Machine	Motor, plastic, glass, rubber, wiring, electrical, concrete, circuit board, heating
IT & Telecom	PC	Metal, plastic, wiring, transformer, circuit board, batteries, CRT, LCD
	Laptop	Incandescent lamp, BFR, metal, plastic, wiring, transformer, circuit board, batteries, CRT, LCD
Consumer	Television	Metal, plastic, CRT, LCD, rubber, wiring, transformer, circuit board, BFR

Table 1 - Major Components in Appliances

Compiled From: (E-WASTE MANUAL, United Nations Environment Programme)[2]

The components found in the WEEE can be categorized as hazardous and non-hazardous materials. *Table2* shows the possible hazardous content in the various components.

Plastic	Phthalate plasticize, BFR
Insulation	Insulation ODS in foam, asbestos, refractory ceramic fiber
CRT	Lead, Antimony, Mercury, Phosphors
LCD	Mercury
Rubber	Phthalate plasticizer, BFR
Wiring / Electrical	Phthalate plasticizer, Lead, BFR
Circuit Board	Lead, Beryllium, Antimony, BFR
Fluorescent Lamp	Mercury, Phosphorus, Flame Retardants
Thermostat	Mercury
BFR – Containing Plastic	BFRs
Batteries	Lead, Lithium, Cadmium, Mercury
CFC, HCFC, HFC, HC	Ozone depleting substances
External Electric Cables	BFRs, plasticizers
Electrolyte Capacitors (Over L/D 25mm)	Glycol, other unknown substances

Table 2 - Possible hazardous substances in WEEE/E-waste component

Compiled from (WEEE and Hazardous Waste, A report produced for DEFRA, AEA Technology, March, 2004)[3]

The substances within the above mentioned components, which cause most concern are the heavy metals such as lead, mercury, cadmium and chromium (VI), halogenated substances

[2] *E-WASTE MANUAL, United Nations Environment Programme – (http://www.unep.or.jp/ietc/Publications/spc/EWasteManual_Vol1.pdf)*

[3] *WEEE and Hazardous Waste, A report produced for DEFRA, AEA Technology, March, 2004*

(e.g. CFCs), polychlorinated biphenyls, plastics and circuit boards that contain brominated flame retardants (BFRs). Other materials and substances that can be present are arsenic, asbestos, nickel and copper. These substances may act as a catalyst to increase the formation of dioxins during incineration.

3 Impact of Hazardous Substances on Health and the Environment

Electronic waste accounts for 70% of the overall toxic wastes which are currently found in landfills, which poses the risk of toxic chemical contamination in soil and other natural resources. The waste from electronic products include toxic substances such as cadmium and lead in the circuit boards; lead oxide and cadmium in monitor cathode ray tubes (CRTs); mercury in switches and flat screen monitors; cadmium in computer batteries; polychlorinated biphenyls in older capacitors and transformers; and brominated flame retardants on printed circuit boards, plastic casings, cables and PVC cable insulation that releases highly toxic dioxins and furans when burned to retrieve copper from the wires. *(Electronic Waste Management in India – Issues and Strategies)* [4] Many of these substances are toxic and carcinogenic. The materials are complex and have been found to be difficult to recycle in an environmentally sustainable manner even in developed countries.

Listed in *Table 3* are the harmful elements in the compositions of electrical and electronic appliances that can be hazardous to health and environment.

Lead	A neurotoxin that affects the kidneys and the reproductive system. High quantities can be fatal. It affects mental development in children. Mechanical breaking of CRTs (cathode ray tubes) and removing solder from microchips releases lead as powder and fumes.
Plastics	Found in circuit boards, cabinets and cables, they contain carcinogens. BFRs or brominated flame retardants give out carcinogenic brominated dioxins and furans. Dioxins can harm reproductive and immune systems. Burning PVC, a component of plastics, also produces dioxins. BFR can leach into landfills. Even the dust on computer cabinets contains BFR.
Chromium	Used to protect metal housings and plates in a computer from corrosion. Inhaling hexavalent chromium or chromium 6 can damage liver and kidneys and cause bronchial maladies including asthmatic bronchitis and lung cancer.
Mercury	Affects the central nervous system, kidneys and immune system. It impairs fetus growth and harms infants through mother’s milk. It is released while breaking and burning of circuit boards and switches. Mercury in water bodies can form methylated mercury through microbial activity. Methylated mercury is toxic and can enter the human food chain through aquatic systems.

[4] *Kurian Joseph (2007) – Electronic Waste Management in India – Issues and Strategies*

Beryllium	Found in switch boards and printed circuit boards. It is carcinogenic and causes lung diseases
Cadmium	A carcinogen. Long-term exposure causes Itai-itai disease, which causes severe pain in the joints and spine. It affects the kidneys and softens bones. Cadmium is released into the environment as powder while crushing and milling of plastics, CRTs and circuit boards. Cadmium may be released with dust, entering surface water and groundwater.
Acid	Sulphuric and hydrochloric acids are used to separate metals from circuit boards. Fumes contain chlorine and Sulphur dioxide, which cause respiratory problems. They are corrosive to the eye and skin.

Table 3 - Harmful Elements in the Compositions of WEEE

Compiled from: ("IT's underbelly", Down to Earth, vol.19, no.1, May16 - 31, 2010)[5]

E-waste typically contains complex combinations of materials and components down to microscopic levels. The wastes are broken down not just for recycling but also for the recoverable materials such as plastic, iron, aluminum, copper and gold. However, since e-waste also contains significant concentration of substances that are hazardous to human health and the environment, even a small amount of e-waste entering the residual waste will introduce relatively high amounts of heavy metals and halogenated substances. Such harmful substances leach into the surrounding soil, water and air during waste treatment or when they are dumped in landfills. Sooner or later they would adversely affect human health and ecology.

For example, most electronic goods contain significant quantities of toxic metals and chemicals like mercury, which is mobile and poisonous in any form - inorganic, organic or elemental. Its organic compound methyl mercury has been scientifically proved to be a neuro-toxin that damages the brain. It is a geno-toxin too, as it passes through the placental and the blood-brain barrier, putting the fetus at risk. Mercury is known to cause severe and permanent damage to the central nervous system, lungs and kidneys. It can trigger depression and suicidal tendencies and cause paralysis, Alzheimer's disease, speech and vision impairment, allergies, hypospermia and impotence. Mercury bio-accumulates (builds up in organisms) and biomagnifies (moves up the food chain). According to the *United Nations Environment Programme's (UNEP) Global Mercury Assessment Report*, even minuscule increases in methyl mercury exposures can affect the cardiovascular system.

Therefore, the health impact of e-waste is evident. There is no doubt that it has been linked to the growing incidence of several lethal or severely debilitating health conditions, including cancer, neurological and respiratory disorders, and birth defects. This impact is found to be worse in developing countries like India where people engaged in recycling e-waste are mostly in the unorganized sector, living in close proximity to dumps or landfills of untreated e-waste and working without any protection or safeguards.

[5] "*IT's underbelly", Down to Earth, vol.19, no.1, May16 - 31, 2010*

4 Benefits from Repair and Reuse of E-Waste

Following are the benefits from Repair and Reuse of E-Waste:

- Gold, platinum, silver, copper, etc. are valuable materials which recyclers recover from e-waste. Experts from the Bonn-based United Nations University provided a financial estimate that the 'urban mining' of e-waste could generate: $21 billion each year ($16 billion in gold and $5 billion in silver).
- Save the manufacturing cost of IC's up to some extent.
- Reduce the amount of precious materials mined from the earth's crust.
- Save our environment from the harm and pollution caused by burning, dumping in landfills etc.
- Companies can cut costs by repairing their old PC's.
- Repaired and refurbished e-waste can be used by the underprivileged.

5 Waste Scenario in India

The electronics industry has emerged as the fastest growing segment of Indian industry both in terms of production and exports. The problems associated with E-waste in India started surfacing after the first phase of economic liberalization, after 1990. Also during the post-liberalization era due to cheaper rate and increase in the per capita income, there was a big boom for the electronic goods industry in India, especially for home appliances (TV, refrigerator, washing machine, AC, ovens, etc.), telecommunication and IT equipment and computers.

PC Sector

It is understood that the IT sector moves according to *Moore's Law* whereby the chip processing power doubles every 18 months. Due to this rapid advancement, the average computer life span has shrunk to less than two years. Each new discovery has the capability of doubling the obsolescence rate as the consumer finds it cheaper and more convenient to buy a new computer machine than to upgrade his old one. *(Scrapping the High Tech Myth: Computer Waste in India)*[6]

Computers that cannot be upgraded increasingly become waste. As indicated by Fig. 1, the sales of PCs in India grew from 1715620 in 2001-2002 to 10800000 in 2011-2012 at about 48% per annum, on average, for the period 2001-2012. *(MAIT[7])*

[6] *Ravi Agarwal, Rakesh Ranjan and Papiya Sarkar for Toxic Links (2003) – Scrapping the High Tech Myth: Computer Waste in India*

[7] *MAIT (2011–2012). Manufacturer's Association for Information Technology Industry performance. Annual Review 2011-12 (http://www.mait.com)*

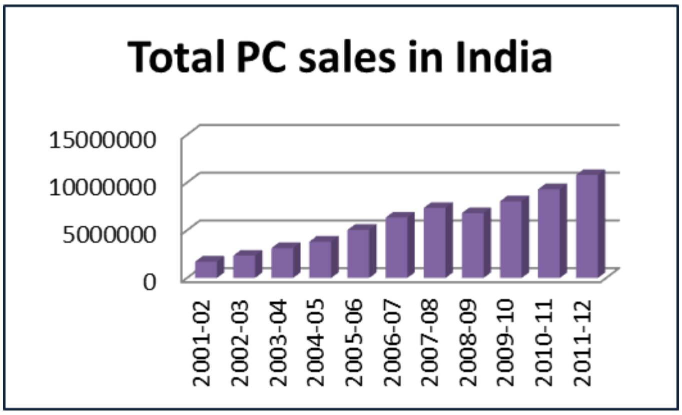

Figure 1 - Total PC (desktop and laptop) sales: 2001-2012 (MAIT)

Computer E-waste emanates primarily from 3 sources in India:

- Individual households
- Business Sector
- Import

1 Individual households

As far as PCs emanating from individual households are concerned, it is difficult to know their condition after leaving the user, as most of them do not directly sell obsolete computers into the scrap market. The preferred practice is to get it exchanged from retailers while purchasing a new computer, or pass it to relatives or friends. In the former case, it is the retailer's responsibility to dispose the computer.

2 Business sector

The business sector (government departments, public or private sector, MNC offices, etc) were the earliest users of IT and IT products and are the major producers of obsolete technology in India. The incompatibility of old systems to cater to present needs and requirement prompts them to pass the obsolete technology to the recycling chain. Most old PCs auctioned are in good working conditions and can potentially be donated or sold for the right purposes.

3 Import

The biggest source of PC scrap is imports. Huge quantities of e-waste like monitors, printers, keyboards, CPUs, typewriters, projectors, mobile phones, PVC wires, etc. are imported. The computers exported are of all ranges, models and sizes, and are functional as well as junk materials. However, due to existence of common HS code for new and old computers and peripheral parts, no data could be furnished on the total amount of obsolete computers being exported from other countries. In any case, existence of international as well as local trade networks and mushrooming of importers of old computers in far flung areas like Darjeeling, Kerala, Kochi, etc., indicate the huge import of obsolete technology in India.

Telecommunication Sector

A recent survey by the *Telecom Regulatory Authority of India (TRAI)*[8] says India is likely to become world's number one mobile market by 2013 with more than a billion mobile users.

The Indian telecommunication Industry is the world's fastest growing telecom industry, with India possessing the second largest telecommunication network after China. The Indian Cellular market grew from 168.11 million in 2003–2004 to 944.81 million in 2011-2012. With the most basic cellphones starting at about Rs.700 to Rs.1000, cellphones have become accessible to the bulk of the Indian population in a very short span of time. The unfortunate side effect of this rapid expansion is the increasingly disposable nature of mobile phones. In urban areas the life cycle of mobile phones is between one and a half to two years.

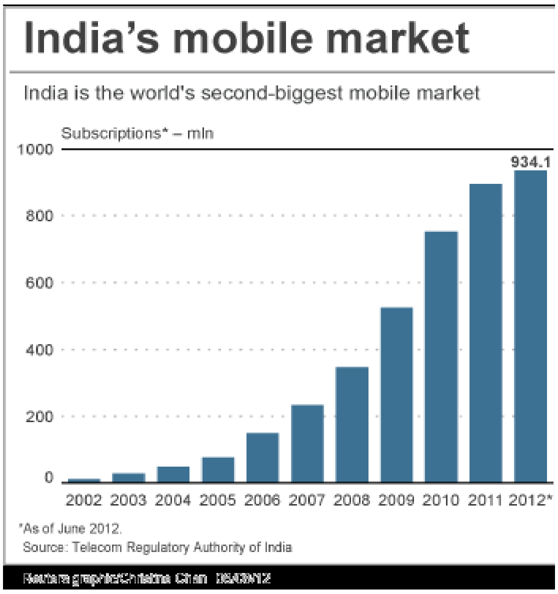

Figure 2 - India's Mobile Market

Home Appliance

The key factors that influence home appliance usage are that the demand for consumer appliances continues to grow and that the replacement cycles of all consumer appliances are shrinking. For example, in the television segment the advents of the Liquid Crystal Display (LCD) and plasma screens have altered the concept of the television for viewers. Better technology has meant improved picture quality and a diminishing price difference between the traditional CRT (Cathode Ray Tube) television and the new flat screen LCD television. The e-waste stream in India currently includes about 100,000 tons of discarded refrigerators (*UNU-Institute for Sustainability and Peace).*

[8] *TRAI (2011-12). Telecom Regulatory Authority of India Annual Report 2011-2012- (www.trai.gov.in)*

Changing consumption patterns

Analysts believe that the electronic industry is going to enjoy a compound annual growth rate of 8 per cent in the period 2010-2014. It is expected that India and other emerging economies will present some of the best markets for consumer spending in the following decade.

Such a prediction would imply that obsolescence would be an ever recurring factor in the growth dynamics of the electronic manufacturing industry. The generation of such obsolete electronic items or e-waste is therefore, likely to increase manifold in proportion to the growth in the electronics industry. Most of the IT products, especially computers and mobile phones, have a short lifespan. The products are not designed for longevity and become obsolete in no time. The most commonly used PC, which earlier had a lifespan of seven years, today has an average lifespan of two to five years. The shorter lifespan of products is a marketing strategy to maintain the pace of consumption and production processes. Therefore, new technologies and 'upgrades' come into the market almost every 18 months influencing consumption patterns.

Further, the availability of choices, changing pace of life, rapid urbanization, and increased purchasing capacity of the middle class have all contributed to the rapid growth of the electrical and consumer durables industry in India. The increasing affordability and availability of these products leads to a gradual penetration into smaller towns which are now showing impressive sales of consumer electronics. The extreme rate of obsolescence compounded by the change in the consumption pattern coupled with indigenous technological advancements, have led to an addition of a wide gamut of E-waste churned out from Indian households, commercial establishments, industries, and public sectors into the waste stream. Solid waste management, which is already a mammoth task in India, is becoming increasingly complex due to the invasion of E-waste.

A MoEF'2012 report says that Indian electronic waste output has jumped 8 times in the last seven years i.e. it is about 8, 00,000 tones now. Another report from Central Pollution Control Board (CPCB) says that around 36,165 hazardous waste generating industries in India accounts for 6.2 million tons of toxic wastes every year.

Sixty-five cities in India generate more than 60% of the total e-waste generated in India. The city-wise ranking of the largest WEEE generators is Mumbai, Delhi, Bangalore, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur. (*E-waste generators raking in money)*[9] While Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab are the top 10 waste generating states in India, generating about 70% of the total e-waste. *(MoEF serious about E-waste disposal)*[10].

[9] *E-waste generators raking in money (http://articles.timesofindia.indiatimes.com/2012-09-26/bangalore/34100765_1_e-waste-recycler-electronic-waste-hazardous-waste)*

[10] *MoEF serious about E-waste disposal (http://articles.timesofindia.indiatimes.com/2012-08-21/lucknow/33302523_1_total-e-waste-e-waste-recyclers-e-wastes)*

6 Present E-Waste Management Systems in India

Before May 2012, India lacked the adoption and implementation of the appropriate framework and guidelines necessary for the safe disposal of e-waste. India has two major types of electronic waste markets, namely the organized and the unorganized market. The unorganized sector is the primary processor of electronic waste in India and deals with 90% of the country's e-waste, although only about 5.7% of the waste is recycled by it. *(E-Waste Recycling In India – Bridging The Gap Between The Informal And Formal Sector[11])*

Most of the activities, right from the collection, transportation, segregation, dismantling etc., are done manually by the 3000 odd dealers in the unorganized sector. In absence of adequate technologies crude methods are adopted which have a significant impact on the worker's health and the environment too. The accrued WEEE in India is dismantled and sorted manually to fractions such as printed wiring boards, cathode ray tubes (CRT), cables, plastics, metals, magnetrons, condensers and other, nowadays invaluable materials like batteries. Improper recycling and disposal operations often involve the open burning of plastic waste, exposure to toxic solders, dumping of acids, and widespread dumping of various WEEE components Waste components which do not have any resale or reuse value are openly burnt or disposed in open dumps. As a result, pollutants are dumped into the land, air, and water, which are the cause of serious environmental problems in India such as fugitive emissions and slag containing heavy metals. Also, the laborers and workers employed in the dismantling and recycling units are underpaid and unaware of the serious occupational health risks associated with these operations. Hammers, chisels, hand drills, cutters, electric torch/burners, and some time electric drills are used to dismantle WEEE *(MPCB 2007)*[12]. In the absence of suitable techniques, infrastructure, and proper Personnel Protection Equipment, the workers and laborers working in such areas are prone to serious occupational health hazards *(EMPA 2004). (The E-Waste Scenario in India: Its Management and Implications)[13].*

Table 4 lists the various hazards to the environment and workers based on the processing of various WEEE components

Computer/e-waste component	**Process**	**Potential occupational hazard**	**Potential environmental hazard**
Cathode ray tubes	Breaking, removal of copper yoke and dumping	Silicosis Cuts from CRT glass	Lead, barium and other heavy metals leaching into ground water and release of toxic phosphor

[11] *Dr. Lakshmi Raghupathy, Mrs Christine, Dr. Ashish Chaturvedi, Dr. Rachna Arora, Mr Mikael P. Henzler - E-Waste Recycling In India – Bridging The Gap Between The Informal And Formal Sector*

[12] *MPCB(2007). Report on Assessment of Electronic Wastes in Mumbai-Pune Area (MPCB report-March, 2007)*

[13] *Sushant B. Wath · P. S. Dutt · T. Chakrabarti(2009) – The E-Waste Scenario in India: Its Management and Implications*

Printed circuit boards	Desoldering and removing computer chips	Tin and lead inhalation	Air emission of the same substances
Dismantled printed circuit board processing	Open burning of waste boards	Toxicity of workers and nearby residents rom tin, lead, brominated dioxin, beryllium, cadmium and mercury inhalation	Tin and lead contamination of immediate environment, including surface and ground waters, brominated dioxins, beryllium, cadmium and mercury inhalation
Chips and other gold-plated compounds	Chemical stripping using nitric and hydrochloric acid along riverbanks	Acid contact with eyes, skin may result in permanent injury. Inhalation if mists and fumes of acids, chlorine and sulfur dioxide gases can cause respiratory irritation to severe effects, including pulmonary edema, circulatory failure and death	Hydrocarbons, heavy metals, brominated substances etc. discharged directly into river and banks. Acidifies the river destroying fish and flora
Plastics from the computer and peripherals	Shredding and low-temperature melting	Probable hydrocarbon, brominated dioxin and PAH exposure to workers living in the burning works area	Emission of brominated dioxins and heavy metals and hydrocarbons
Secondary steel or copper and precious metal smelting	Furnace recovers steel or copper from waste	Exposure to dioxins and heavy metals	Emission of dioxins and heavy metals
Wires	Open burning to recover copper	Brominated and chlorinated dioxin and PAH exposure to workers living in the burning works area	Hydrocarbon and ashes, including PAHs discharged into air, water and soil

Table 4 - Lists of various hazards to the environment and workers

Compiled from: (E-waste hazard: The impending challenge, Violet N. Pinto (2008))[14]

[14] *Violet N. Pinto (2008) – E-waste hazard: The impending challenge, Violet N. Pinto (2008) (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2796756/)*

The organized market though present in India has a very small foothold in WEEE management. E-waste recycling can be undertaken only in facilities authorized and registered with State Pollution Control Boards/Pollution Control Committees while *the Guidelines for Environmentally Sound Management of E-waste* published by *the Central Pollution Control Board (CPCB)* provide the approach and methodology for environmentally sound management of e-waste. Due to high capital requirements and the relatively low volumes of e-waste processed by the organized recyclers, authorized recycling of e-waste is still in its nascent stage. The highest density of authorized dealers is found in places like Chennai, Noida and Bangalore where the e-waste production by the IT sector is the highest. There are only about 73 authorized recyclers of WEEE in India. The organized market deals almost entirely with a select group of large IT corporations and misses out on smaller institutions and households. Lack of public awareness of the proper WEEE disposal methods hinders the growth of the organized dealers.

7 Laws and Framework Dealing With E-Waste Management

The Electronic Waste (Management and Handling) Rules, 2011 in effect since 1st May, 2012 have put India in a select group of nations that have the legislation necessary to deal with the management of WEEE. These rules come in the place of *"The Hazardous and Waste Management Rules, 2008"*, under the *Environment Protection Act (EPA)*. The new directive has 6 chapters covering electrical and electronics waste handling, responsibilities, recycling, etc. As per the new rules, 'E-waste' is defined as waste electrical and electronic equipment (WEEE), whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded. The concept of Extended Producer Responsibility (EPR) has been enshrined in these rules. As per the rules, producers are required to collect E-waste generated from the end of life of their products by setting up collections centers or take back systems either individually or collectively. Waste generated is required to be sent or sold to a registered or authorized recycler or re-processor having environmentally sound processing facilities. The Guidelines for Environmentally Sound Management of E-waste published by CPCB provide the approach and methodology for environmentally sound management of e-waste. They provide approach for setting up collection mechanism, dismantling and recycling operations. *(India gets first e-waste management rules)*[15] It also restricts the usage of certain hazardous substances in electrical and electronics equipment. This section is very similar to the European Union's RoHS directive; but there is a two year time period to achieve this and it will be in force starting 1st May 2014. By then manufacturers will have to start introducing greener products that exclude or reduce levels of these toxic substances and they will also have to ensure that consumers are aware of the hazardous compounds present in their products. They will have to provide information on the proper disposal of e-waste. If the waste is collected and channelized in a proper manner, many of the challenges of waste management should be addressed properly in the future.

[15] *India gets first e-waste management rules (http://www.business-standard.com/article/economy-policy/india-gets-first-e-waste-management-rules-111060900037_1.html)*

8 Preventive Measures

- Implementation of the newly passed *Electronic Waste (Management and Handling) Rules,* is the biggest hurdle being faced right now. The Government should ensure that the laws are enforced throughout these formative years.

- The legislation should ensure that the sale of environmentally friendly products to consumers is incentivized. Manufactures should also be required to incentivize the return of old and damaged products. Thus ensuring that the waste is sent exclusively to authorized recycling facilities.

- Future changes in policy should address the pitiful working conditions in the recycling industry in India, where low-skilled labor is abundant and people are desperate for any income. This could be achieved by integrating the informal scrap dealers, of all forms of electronic and electrical waste, into the formal sector. Making these people aware of the health hazards faced by them is of paramount importance.

- Awareness of the grave environmental and health effects caused due to the informal treatment of e-waste is almost non-existent among consumers. Awareness can be spread through advertisement campaigns, awareness camps in schools, colleges and communities so as to exponentially increase the number of people using authorized e-waste management centers.

- Civic bodies must sponsor and set up even more authorized centers for e-waste processing and management in collaboration with various manufacturers and NGOs. If observations made by environmental NGOs are anything to go by, efforts over the past year to improve disposal mechanisms have been negligible. The newly formed rules do not mention the number of collection points, or even the number of authorized recyclers required in cities. Environmentalists believe that this might result in manufacturers setting up a few symbolic collection centers across the country which might not be able to deal with the quantity of waste produced. *(Electronic waste rules: In letter, but without spirit)* [16]

[16] *Electronic waste rules: In letter, but without spirit (http://blogs.reuters.com/india/2012/05/17/electronic-waste-rules-in-letter-but-without-spirit/)*

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About The Author

Udit Jain is a Grade 11 student of the National Public School, Bangalore, India. He is extremely passionate about environmental conservation and technology which led him to write this paper on E-waste. He founded the Social Responsibility Club in his school and is actively involved in various altruistic endevours.

THE RELATIONSHIP BETWEEN HEAVY METALS AND SEDIMENTARY ORGANIC MATTER IN ESTUARY SEDIMENT OF SUNGAI PERLIS, PERLIS, MALAYSIA

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Abstract

A study of relationship between heavy metals and sedimentary organic matter in estuary sediments was carried out along Sungai Perlis during Southwest monsoon (May-July 2011), and Northeast monsoon (November 2011 - January 2012). Result indicate that, for all seasons, the concentration of As was range from 11.88 to 59.12 µg/g dry weights, Cd from 0.02 to 0.17 µg/g dry weights, Cr from 56.67 to 158.23 µg/g dry weights, Cu from 10.22 to 34.47 µg/g dry weights, Pb from 31.19 to 70.62 µg/g dry weights and Zn from 61.29 to 121.10 µg/g dry weights. The average trend of the heavy metals distribution along Sungai Perlis as follow; Cr>Zn>Pb>As>Cu>Cd. Meanwhile, the percentage value of organic matter content of sediment was shows slightly higher during Southwest Monsoon compared to the Northeast Monsoon which was 7.43±1.55% and 6.75±1.72%, respectively. The relationship of heavy metals concentration with the organic matter for all seasons and stations are proven statistically via Pearson Correlation Analysis. As a result, all metals except As and Cu has a significant correlate with p-value bellow than 0.05.

Keywords: Heavy Metals, Organic Matter, Pearson Correlation, Estuary Sediment.

Introduction

Nowadays, most significant attention has been paid due to the problems of environmental contamination by heavy metals (Eldemerdash and Elegamy, 1999). Heavy metals are one of the natural components of the earth's crust that can enter the water cycles through variety of processes. The pollution comes out from heavy metals has drawn an increasing attention worldwide due to a dramatic increase of anthropogenic heavy metal to the ecosystems through air, water and soils. Most of previous studies showed that heavy metals are among the most common environmental pollutants due to its toxicity, persistence, and non degradability in the environment (Louma, 1983).

The toxicity of heavy metals has long been of great concern since it is very important to the health of people and ecology (Feng et al., 2008). Heavy metals are of the major concern due to their persistent and bio-accumulative nature. According to Kim et al., (2002) and Lee et al., (2001), heavy metal is one of the pollutants that contribute serious adverse effects to aquatic pollution. These elements can be discharge through anthropogenic sources and collective into receiving systems such as sediments, soil and water. Heavy metals are non-degradable and very harmful to plants, aquatic organism and human at certain levels of exposure (Mustafa and Nilgun, 2006).

Accumulation of heavy metals in sediments is largely controlled by their geochemistry such as type and quantities of organic matter, grain size and cation exchange capacity (Vertacnik et al., 1995). The burial of organic matter in margin sediments provides the primary long-term sink for reduced carbon in the ocean (Berner, 1982). River-dominated margins are quantitatively important sites for organic matter accumulation and its organic matter content become as a crucial factor in determining the extent of sorption (Means et al, 1980).

The distribution of heavy metals in sediments approves that the influences of anthropogenic sources gives impact on aquatic ecosystems (Tsai *et al*., 2003). The organic matter decides the site of deposition of metals due to its ability of adsorption leads to strong correlation between it and metal elements (Gonzalez *et al.,* 1991). As mentioned by Wang and Chen, (2000), organic matter content was most important factors than grain size in controlling the distribution of trace metals in the sediments. The different mobilities of each sediment fractions can influences the trace metal distribution accumulates in sediments (Katz and Kaplan, 1981).

Therefore, Sungai Perlis Estuary in Perlis is a good example of a site where human pressures and natural values compete with each other. The river basin is approximately 310 km^2 with the length is about 11 km through Kangar city to Kuala Perlis, Perlis, Malaysia. Sungai Perlis is classified as a Class III river. It is currently experiencing heavy erosion at its river banks and has become very shallow. Rubbish that has been thrown into the river is therefore very visible and it is not accessible to boats. There is a former landfill located in Kuala Perlis and these directly affect the water quality of the river and contribute to increasing of sediment contamination. Other point source pollution includes shrimp livestock ponds, Kangar Wet Market, Food stalls and the Kuala Perlis Fisherman Jetty. Due to this, the research will serve as a guideline that is needed prior to the development of the Sungai Perlis as a developing area. One of the aims of this study is to investigate the correlation between heavy metal and organic matter.

Materials and Method

a) Study area.

Generally, Sungai Perlis was located at latitude of 6° 22' 60 N and longitude of 100° 17' 60 E, Northern part of Malaysia (Figure 1). There are, ten stations were established along the Sungai Perlis during Southwest monsoon (May-July 2011), and Northeast monsoon (November 2011 - January 2012)and marked using GPS (Global Positioning System). These locations were selected based on the fact that they might have been impacted by the nearby source of contamination. The distance between each station was approximately 1 km. Riverbed sediment samples were collected using the Van Veen Grab, where afterwards, samples were placed in plastic bags which were previously immersed in 5% nitric acid for two to three days to prevent sample contamination. The sediment samples were then preserved in the ice-box at 4oC to maintain the original condition of the samples. At the laboratory, samples were dried in the oven at 105oC for 24 hours. For heavy-metal and organic matter analysis, it were ensured that the samples had been completely dried before grinding the samples with mortar and pestle and sieved under 63µm size. Precautions in preventing sample contamination were given priority. Samples were then stored in labelled plastic vials and kept in the drying cabinet until lab analysis.

b) Sample Digestion

In this study, the digestion and analytical procedures were adopted and applied from that of Tsugonai and Yamada (1980), Kamaruzzaman (1999) and Jamil (2006) with little modifications. For this analysis, 0.05 g of the fine powder sediment (<63µm) was weighed and put into a Teflon vessel. After that, 1.5 ml of mixed acid (2.5 HF: 3 HNO3: 3 HCL) was added into the Teflon vessels using a single channel pipette, 100-1000 micro litre (µl) of the brand CappAero which was ISO 9001; 2000 certified. This digestion method is also known as the aqua regia + HF digestion method, which was also applied by Trimm et al. (1998) and Chen and Ma (2001). Finally, the Teflon Bomb jackets were screwed tightly to prevent the appearance of silicate gel on their bodies, before placing the Teflon bombs into the oven for 6 hours at 160˚C. After 6 hours, they were cooled down under room temperature where after that, 3.0 ml of acid solution composed of ethlenediaminetetraacetics acid (EDTA) and Boric acid were added. The samples were then again put into the oven at 160˚C for another 6 hours. The clear solution obtained was transferred into centrifuge tubes and meshed-up to 10 ml with Mili-Q water. To verify the precision of the analytical procedures, the sediment samples were analysed in three replicates for each sampling point and a sample blank. While to confirm analytical accuracy, portions of certified reference materials (SRM1646a - estuarine sediments) from the National Institute of Standards and Technology (NIST) were analysed with each batch of samples. The concentrations of metals (Cd, Co, Fe, Pb and Zn) in the final digested solutions were then analysed using the Inductively Coupled Plasma Mass Spectrometer (Perkin Elmer. Elan 9000).

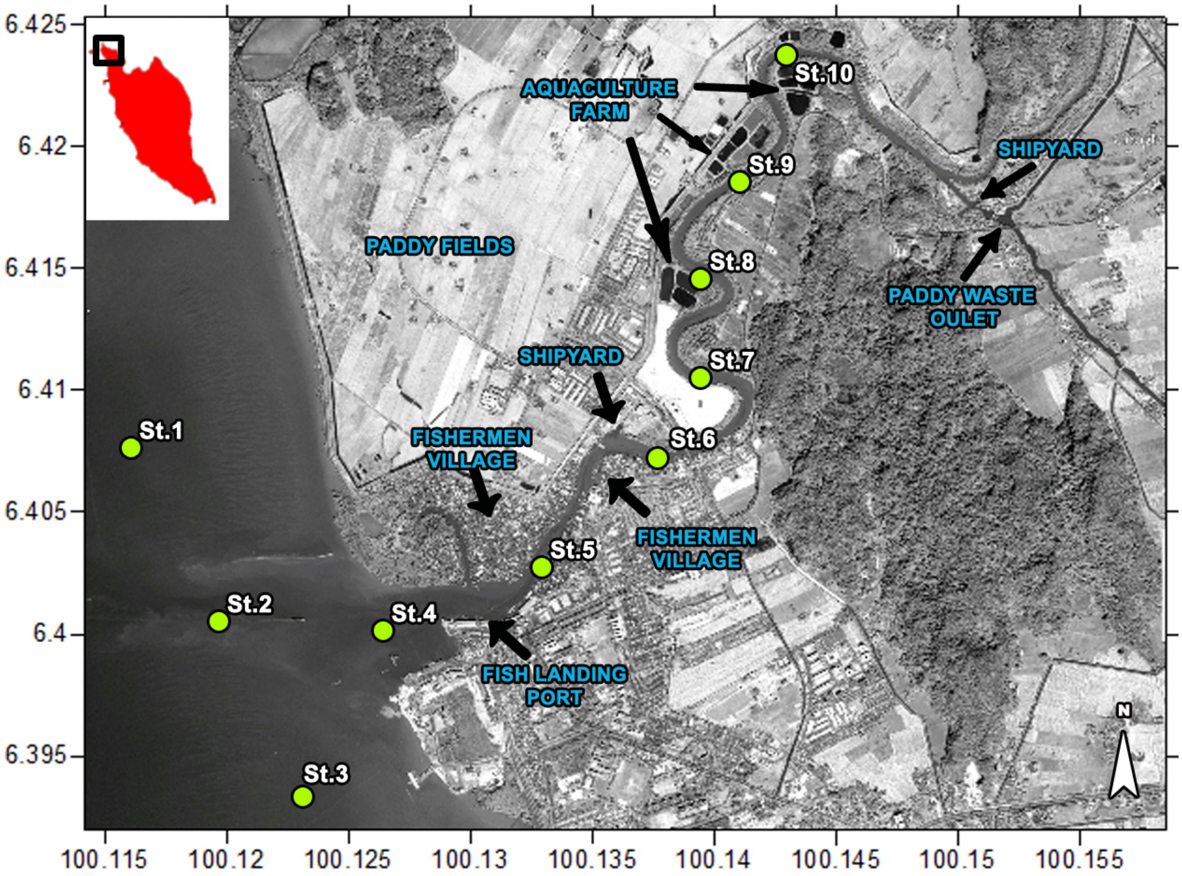


Figure 1: Map of Sungai Perlis

Table 1: The sampling coordinates of Sungai Perlis

Sampling Stations	**Latitude**	**Longitude**
ST 1	6°24'27.72"N	100° 6'56.46"E
ST 2	6°24'2.04"N	100° 7'6.72"E
ST 3	6°23'42.00"N	100° 7'20.22"E
ST 4	6°24'1.62"N	100° 7'34.92"E
ST 5	6°24'10.68"N	100° 7'58.44"E
ST 6	6°24'26.22"N	100° 8'15.30"E
ST 7	6°24'38.10"N	100° 8'22.02"E
ST 8	6°24'53.70"N	100° 8'22.32"E
ST 9	6°25'7.20"N	100° 8'27.72"E
ST 10	6°25'26.10"N	100° 8'34.08"E

c) Determination of organic matter

For this analysis, the methods of loss on ignition method were applied. This method is refereed to ASTM D 2974 - Standard Test Method for Moisture, Ash and Organic Matter of Peat and Organic Soils. By using this method, 1g of fine soils is dried in oven at 105^{O}C for 2 hours and continues till get a constant weight. Weigh and record the empty and dry porcelain dish (MP). Put 1 g of fine soils (<63mm) into porcelain dish and re-weigh porcelain dish (MPDS). Put the porcelain dish in muffle furnace. Gradually increase the temperature in furnace to 440^{o}C. Leave the dish in furnace for overnight. The next day, removes the dish and allows to cools at room temperature. Reweigh and record the dish contain ash (MPA).

$$\textbf{\% Organic matter} = (M_O / M_D) \times 100$$

Where, M_O = mass of organic matter, $M_O = M_D - M_A$

M_A = mass of ashed soil, $M_A = M_{PA} - M_P$

M_D = mass of dry soil, $M_D = M_{PDS} - M_P$

Result and Discussion

For method validation, Certified Reference Material (SRM1646a) was determined as a precision check. The percentage of recoveries (n = 6 for each metal) for certified and measured concentration of those metals was satisfactory, with the recoveries being 81.67 – 96.15%. Table 2 shows the recovery test results for SRM (1646a) analysis.

Table 2: Recovery test results (concentration for all metals are in µg/g dry weight)

Heavy Metals	Measured SRM	Certified Value	Recovery (%)
Arsenic, As	5.99±0.32	6.23±0.21	96.15
Cadmium, Cd	0.127 ± 0.011	0.148 ± 0.007	85.81
Copper, Cu	8.67±0.65	10.01±0.34	86.61
Chromium, Cr	38.87±0.56	40.9±1.9	95.03
Lead, Pb	9.552 ± 0.473	11.7 ± 1.2	81.67
Zinc, Zn	45.389 ± 0.698	48.9 ± 1.60	92.82

From this study, the heavy metal contents of the sediment were analysed and the results were depicted in Table 3. According to this table, the concentration of all elements along the stations was constantly increased toward the upstream area for both seasons. The highest value was recorded at the area near to the aquaculture activities, paddy field Outlet and also domestic area (St 8, 9 and 10). As a seasonal comparison, during the Southwest Monsoon (SWM), Zn was recorded the highest value of heavy metal concentration with the average value of 94.45±18.57 µg/g dry weight, Followed by Cr, Pb, Cu, and As with the average concentration of 93.09±18.35 µg/g dry weight, 39.22±8.18 µg/g dry weight, 23.63±8.87 µg/g dry weight, and 19.74±5.86, µg/g dry weight, respectively. However, the concentration of Cd in the study area was indicated slightly higher in some station (ST8) with the value of 0.21 µg/g dry weight. Meanwhile, during NEM season, heavy metal distribution trends have been changed, some of heavy metal was slightly higher than SWM season accepted Cd, Cu, and Zn. From the results, the concentration of Cr was obtained the highest among the other metals with the average value of 112.83±25.81 µg/g dry weight. According to statistical analysis (one-way ANOVA), As, Cr, Pb were significantly difference between the seasonal changes with the p-value bellow than 0.05. Whiile, all metals were shown insignificantly differences between the sampling stations. In general, the average trend of mean concentration of heavy metals in Sungai Perlis, Malaysia during SWM and NEM seasons can be expressed as Zn>Cr>Pb>Cu>As>Cd and Cr>Zn>Pb>As>Cu>Cd, respectively.

Moreover, regarding to the Table 3, the percentage of organic matter content (OM) of sediment was slightly higher during the SWM season (7.43±1.55%) compared to the NEM season (6.75±1.72 %) with the different value of 0.68%. The highest percentage of OM was found in St.8 during SWM season, with a value of 9.08%; the lowest percentage was obtained at in St.1 (4.93%). However, during the NEM season, the highest and the lowest percentage of OM were recorded at St.10 (8.30%) and St.3 (3.88%), respectively. Statistical analysis (one-way ANOVA) shows no significant difference for both seasons and significantly difference between the sampling stations.

According to Macalady and Ranville (1998), natural organic matter is complex and may have unique combinations of functional groups The quantity of organic transported by rivers is well-documented (Meybeck, 1982; Degens et al., 1991). The major source of organic matter is derived from domestic, agricultural and industrial wastes which are difficult to quantify but likely contribute significantly to the global budget. The organic material distribution in estuary systems and rivers tends to be dissimilar. The concentration of organics in water or bottom sediments is influenced by natural and anthropogenic sources. Besides, the complex behavior of estuaries that comes from many processes including physical, chemical, and biological can cause a differences in organic distribution.

The distribution of heavy metals in sediments approves that the influences of anthropogenic sources gives impact on aquatic ecosystems (Tsai *et al*., 2003). The organic matter decides the site of deposition of metals due to its ability of adsorption leads to strong correlation between it and metal elements (Gonzalez *et al.*, 1991). As mentioned by Wang and Chen, (2000), organic matter content was most important factors than grain size in controlling the distribution of trace metals in the sediments. The different mobilities of each sediment fractions can influences the trace metal distribution accumulates in sediments (Katz and Kaplan, 1981). On the other hand, heavy metals also generally have significant correlation with OM content (Price, 1976 and Yu et al. (2001),). According to Veeh (1967) and Jones (1974) reported that organic matter can act as an agent to trap metals within the sediment.

Table 3: Data for heavy metal and organic matter (concentration for heavy metal is in µg/g dry weight and organic matter in percentage)

Station	As		Cd		Cu		Cr		Zn		Pb		OM	
	SWM	**NEM**	**SWM**	**NEM**	**SWM**	**NEM**	**SWM**	**NEM**	**SWM**	**NEM**	**SWM**	**NEM**	**SWM**	**NEM**
St.1	11.88	15.52 [a]	34.47	10.22	77.01 [a]	76.73	0.04 [a]	0.02 [a]	84.12	62.82	33.34	39.71	4.93 [a]	3.92
St.2	13.98	23.65	14.49	16.76	82.34	105.27	0.04 [a]	0.10	73.99	86.16	31.19	46.83	6.14	6.86
St.3	18.98	26.48	19.74	7.32 [a]	90.85	70.91 [a]	0.10	0.06	89.08	61.29 [a]	38.42	32.46	4.94	3.88 [a]
St.4	11.47[a]	32.87	8.01 [a]	18.13	56.67	114.47	0.04 [a]	0.17 [b]	62.2 [a]	95.33	23.54 [a]	52.16 [a]	8.18	7.86
St.5	20.19	26.41	22.74	15.16	113.17	103.54	0.12	0.1	107.63	78.48	45.87	43.47	8.69	5.58
St.6	24.98	29.59	29.03	23.34	100.76	115.34	0.17	0.13	109.69	89.53	45.62	48.32	8.83	6.97
St.7	26.36	26.27	30.57	28.53	109.38	124.44	0.14	0.1	111.04	96.64	45.97	48.57	8.06	7.79
St.8	21.47	35.72	21.43	20.73	96.52	158.23 [b]	0.21 [b]	0.16	100.34	117.37*	42.66	63.99	9.08 [b]	8.09
St.9	19.94	77.50 [b]	19.86	26.4	87.52	126.75	0.08	0.14	85.35	110.03	36.19	76.88 [b]	7.71	8.28
St.10	28.13[b]	59.12	35.91 [b]	35.29 [b]	116.64 [b]	132.60	0.14	0.16	121.10 [b]	107.3	49.44 [b]	70.62	7.75	8.30 [b]
Average	**19.74±5.86**	**35.31±18.71**	**23.63±8.87**	**20.19±8.52**	**93.09±18.35**	**112.83±25.81**	**0.11±0.06**	**0.11±0.05**	**94.45±18.57**	**90.50±18.95**	**39.22±8.18**	**52.30±14.01**	**7.43±1.55**	**6.75±1.72**

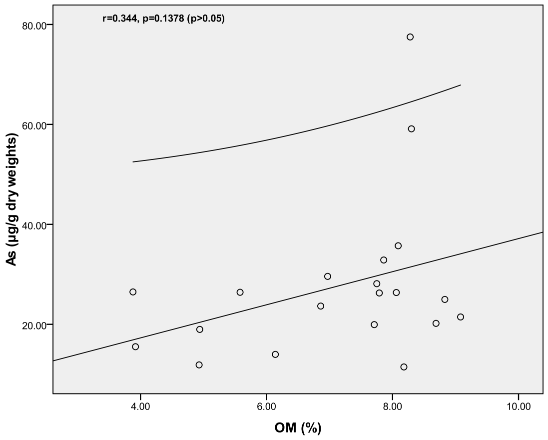
[a]= minimum value
[b]=maximum value
SWM=Southwest Monsoon
NEM=Northeast Monsoon

The significant relationships between concentration of heavy metals and OM content were further established by performing Pearson correlation analysis (Figure 2). From the observation, Cd and Zn were strong positively correlated with the ‘r-value’ of 0.716 and 0.701, respectively. Statistical analysis revealed the strong binding of OM with heavy metals in the study area. In general, the high percentage of organic material in these sediments is it was believed from anthropogenic sources. The accumulation of OM will increase the probability of high concentrations of heavy metals deposited in the study area. According to Chou et al. (2002), heavy metal concentrations were found to be higher when the total organic matter content was high in sediments.

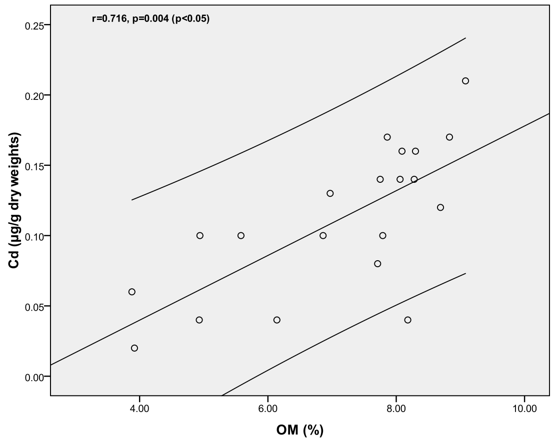
From observation, stations that are in the upstream area (St7 – 10) showed the highest average vakue for Cd, Zn and %OM. The highest value may be due to the aquaculture activities and also fertilizer that used in agriculture activities (paddy field). Wastes from the aquaculture farm and paddy field were discharged directly into the surrounding aquatic environment, untreated, often containing antibiotic, pesticides and also fertilizers. According to Chou et al. (2002), an accumulation of heavy metals on the riverbed near the aquaculture farms, particularly zinc. Moreover, Burridge et al. (1999) was stated that Cd can exceeded till 0.7 $mg \cdot g^{-1}$ in the sediment near the aquaculture farms.

On the other hand, the other anthropogenic sources of Zn and Cd in sediment are fertilizers. From the observation, at present, farmers in this area have used fertilizer trace elements, consisting of Zn (16%), B (2.5%), Cu (0.5%), Fe (2%), Mn (5%), Mo (0.1%) and Si (5%) for their paddy. While, according to Finnish Ministry of Agriculture and Forestry, (2000), Cd can be present in this study area might be from the phosphorus-fertilizers, atmospheric deposition, animal manures, and to a smaller extent liming agents, sewage sludge and bio-waste. Lu et al. (1992) reported that the phosphate fertilizers were generally the major source of trace metals among all inorganic fertilizers, and much attention had also been paid to the concentration of Cd in phosphate fertilizers. The great majority of agricultural soils in Malaysia are heavily fertilized by this kind of fertilizers, which was reported by Zarcinas *et al.* (2004). According to Habibah et al (2011), the total Cd concentration in the paddy soil samples (Yan, Kota Setar, Kubang Pasu and Bumbung Lima) were ranged from 3.54 to 20.86 mg/kg.

Furthermore, weathering process of dolomite or limestone was play an important role increase the the anthropogenic sources of heavy metal especially Zn. Genesio, (2011), was stated that the areas are underlain by limestones of varying age, most of which host lead / zinc / silver mineralization, intermingled with three major granitic intrusive belts. According to Price (2011), Perlis is a small state in northern Malaysia, and it has both isolated tower karst hills as well as a long range of limestone hills. Besides that, the possible sources of Zn in the study area were from domestic waste, shipyard, automotive and industrial effluent. On the other hand, household products includes powder and liquid laundry detergents, shampoos, toilet tissue and other cleaning product may also contribute to the zinc load into the aquatic environment (EIP, 1999).



(a)



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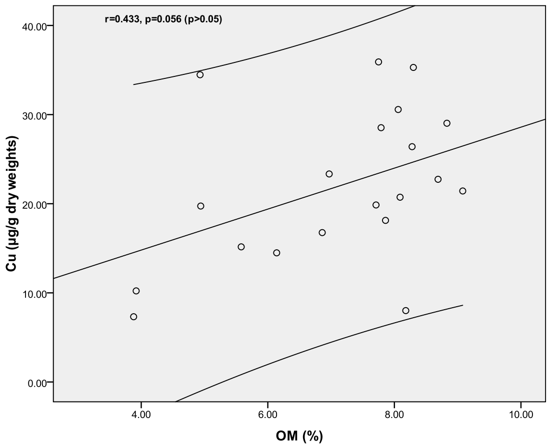

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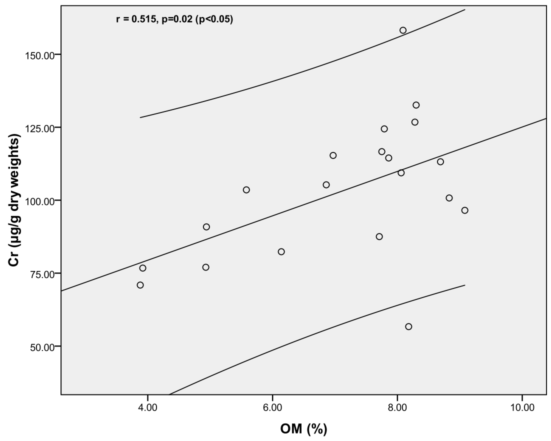

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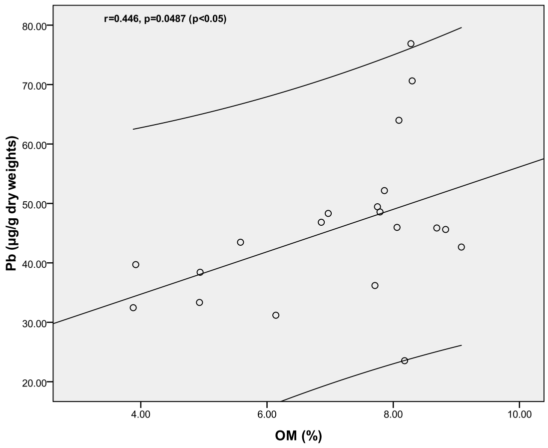

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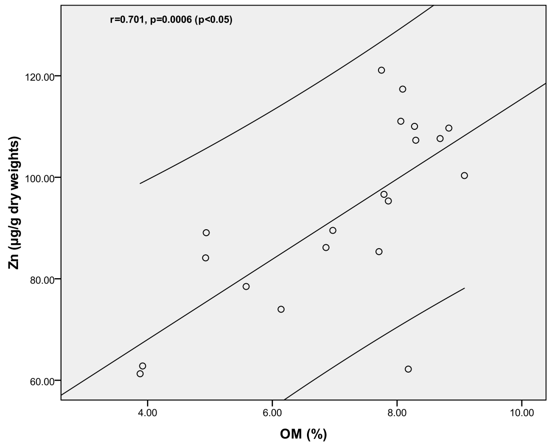

(f)

Figure 2: The Pearson correlation between heavy metals and organic matter.

For Cr and Pb, the Pearson correlation was shown significantly correlated, where the ‘r-value’ for both elements was 0.515 and 0.446, respectively. This indicates that the relationship between these elements with OM was in the medium level. From these observations, the presence of Cr into this area is the possibility from renovation of irrigation canals gate that was conducted close to St.10. It is believed that the cement used in this renovation process earlier was leached by rainwater or flush via river runoff, and then this element settles down in the bottom sediment. According to ATSDR (2008), the environmental sources of chromium are mainly from cement dust (cement contains chromium), the wearing down of asbestos linings that contain chromium, emissions of chromium-based automotive catalytic converters, and tobacco smoke. On the other hand, the chromium source in aquatic ecosystems is domestic waste water effluents with the percentage value of 32.2% in total (Barceloux 1999).

Residual lead (Pb) in water also contributes to lead exposure in this study area. These residual was expected from the small shipyard that was located at the upstream area and the middle of the river. As yard to service a small boat, used engine oil may overflow from the docks that can cause high levels of Pb concentration in the sampling stations. From the other research, Woolf, *et. al.*, (2007) was stated that, Pb content in sediment may be caused by broken-down lead paint, residues from lead-containing gasoline, used engine oil, or pesticides used in the past, contaminated landfills, or from nearby industries such as foundries or smelters. Other than Pb, Cu also caused by

Based on these studies, the weak correlation ($p>0.05$) for both Cu and As with OM content in sediment indicating that OM was not major factors to control the Cu and As distribution. . This weak correlation may be the result of complex geochemical reactions and it is not as easy as sedimentation process (Morse *et al.* 1993). Furthermore, the environmental condition of the river such as discharges of upstream pollutants, and alternation between fresh water and sea water may be very complicated so that very little correlation between these metals and OM content.

Conclusion

From this study, the overall trend of mean concentration of heavy metals in Sungai Perlis can be concluded by the following order Zn>Cr>Pb>Cu>As>Cd during SWM and NEM seasons can be expressed as Cr>Zn>Pb>As>Cu>Cd, Beside that, the percentage of organic matter content (OM) of sediment was slightly higher during the SWM season. According to Pearson correlation analysis, all elements a significantly have relationship ($p<0.05$) between heavy metal and OM accept As and Cu. From this study, it can be concluded, aquaculture waste, domestic sewage and paddy waste were influence the distribution of heavy metal and percentage of OM.

Acknowledgment

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The Use of Narrow-Band NDVI as a Biomass Predictor for Algae of Sabkha Environment

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Abstract

The overall utility of a visible/nearinfrared images and spectral profiles has several advantages and applications in environmental and ecosystem investigations. In the present paper, a close-range remote-sensing technique is used for assessing algal communities within the sabkha environment. The area is partially covered by mangrove trees and has salt flat areas without visible algal mat. Other locations have dark brown and green patches of algae especially in the supratidal area. Those considered as the most important organisms living in the sabkha habitat. Visible and infrared electromagnetic bands were used to characterize productivity, biomass, and distribution of the algal communities in the sabkha environment. To accomplish this, the study tested the use of the well-documented ratio of near-infrared (NIR; 800nm) to red (670nm) reflectance in order to characterize the living component in the Sabkha area of Abu Dhabi. Multispectral visible/nearinfrared camera was used to collect images from the area of interest. The reported analysis characterized two types of algae; namely active and non-active algae. The active algae has high near-infrared (NIR) band reflectance and lower red band reflectance. However, inactive algae have low NIR band reflectance and higher Red band reflectance. The study also reported field observations, computer vision approach and remote sensing indicators that are useful in order to study the relation between spectral reflectivity and algal characteristics.

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Keywords: *Remote Sensing, NDVI, Spectra, Sabkha, Biomass*

1. Introduction

Remote sensing and spectroradiometry are useful tools in accomplishing several mapping, spectral analyses, and environmental/ecological assessment goals, including assessing the distribution of biomass, and nutrient status of ecosystems. For example, the ability of algae to reflect or absorb light is dependent on its morphological and chemical characteristics which, in turn, are a function of algal conditions, chlorophyll type, nutrient, health, and growing conditions. The relation between spectral reflectivity and plant status makes remote sensing and spectral analyses potential tools for studying ecosystems. In the present paper, a close-range remote-sensing technique is used for assessing algal communities within the sabkha environment in United Arab Emirates.

The study area is covered with blue-green algal mat. This algal mat can be considered as immature source rock for oil that can reach maturation upon proper thermal treatment. We plan to use remote sensing, field sampling to study their distribution and infer their biomass. Hence, the present study hypotheses that ecosystem component in the sabkha environment reflects infrared in proportions that differ sharply from that of visible light. The tonal relationships in conjunction with spectral vegetation indices are useful tool to infer and predict sukkah's environment characteristics and properties

2. Location of the Study area:

The study area is located in the coastal area of Abu Dhabi in United Arab Emirates (Fig. 1). This area is characterized by the presence of flat, salt-encrusted surfaces covered by a thin layer of blue-green algae. These areas are known by the Arabic name (sabkha). The area lies between 20°50' and 26°N and 51° and 56°E, and is up to 16 km wide, with average slope of 1:3000 and situated above the level of present-day high tide in the so-called supratidal zone. The monthly average air temperature of the coasts in the vicinity of Abu Dhabi ranges from 47º C to 12º C, but the temperature of the surface of sabkha can reach 60º C or more in summer. Sabkhas form unique environmental and geological settings that attracted the attention of researchers for a long time. Earlier work on the area dates back to the sixties of the last century and emphasized on the discovery of the relation between carbonate and evaporite sediments in what had been known as the sabkha-sequence by Shearman (1963, 1965, 1978) and Evan et al., (1969), made this region, the centre of attraction for algal mat and carbonate-evaporite students from all over the world, due to the significant implications of that discovery in understanding the mechanism, which formed most of the carbonate oil reservoirs, particularly in the Arabian Basin. Sabkhas are believed to be important depositional environments during the geologic history in different parts of the world.

3. Methodology and observations:

Field visits and data collection took place during February and March of 2012. The visited locations share certain similar characteristics and always very close to the local water table, usually, within about a meter. In late February and March usually several dozen square of kms are flooded up to a depth of 50cms. In these areas groundwater is drawn towards the surface by capillary action and evaporates in the upper subsurface in response to the high temperatures (Bryant et al., 1994). There, it deposits common evaporates including, calcium carbonate, gypsum ($CaSO_4.2H_2O$), anhydrite ($CaSO_4$) and sodium chloride or halite ($NaCl$), which precipitate in that order. These salts create a hard, impermeable crust in a zone about half a meter below the surface. This crust, along with high salinity, discourages all plant growth (except the stromatolites), and has other negative environmental impacts. For example the crust will impedes the drainage of surface water, so that after rains the sabkhas flood; if these conditions were to migrate, it will pose harmful effects to the hosting areas (e.g. risks to recharge areas, agricultural areas and urban as well).

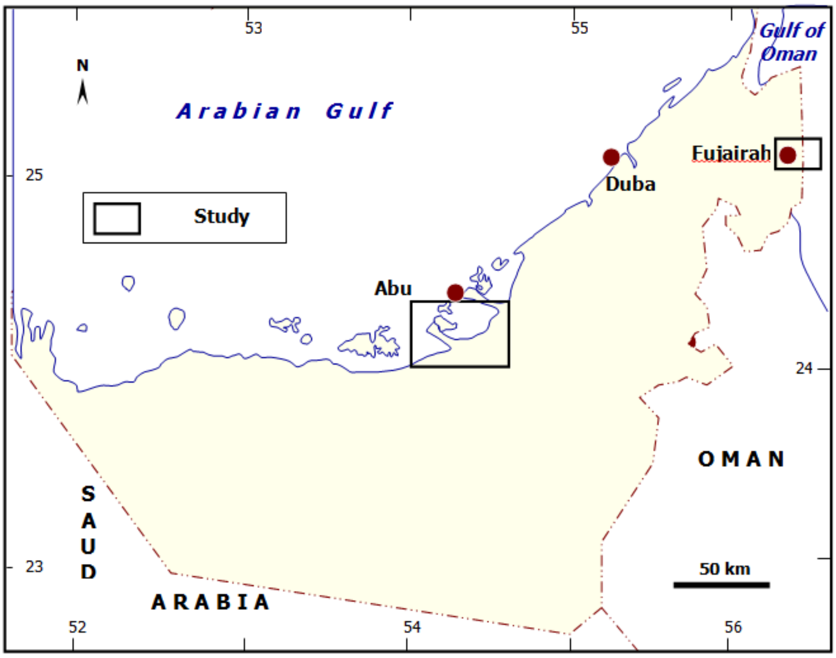

Figure 1. Location of the studied sabkhas in the vicinity of Abu Dhabi

To identify areas with green biomass the Normalized Difference Vegetation Index (NDVI) is calculated. The NDVI is graphical indicator that can be used to study remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not. It is a commonly used index by researches in the remote sensing community to assess the live vegetation level in a certain area. To calculate the NDVI both the NIR and the red bands are utilized as follows:

$$NDVI = \frac{NIR - \mathrm{Re}\,d}{NIR + \mathrm{Re}\,d}$$

Toward this end, the study used JAI's AD-080GE camera which is prism based 2-CCD progressive area scan camera to obtain images and spectral profiles for the study area. This camera is capable of simultaneously capturing visible and near-infrared light spectrums through the same optical path using multi- channels. The first set of images were taken by the first channel which has a Bayer mosaic color imager that captures visible light, while the second set of images were taken by channel that has a monochrome sensor for capturing near infrared light. We also created RGB images by loading three different grayscale images into the R, G and B channels.

4. Results and discussion:

Figure 2a and b shows an overview of the study area. As can be seen, the area is partially covered by mangrove trees and has salt flat areas without visible algal mat. Other location has dark brown and green patches of algae especially in the supratidal area. Those considered as the most important organisms living in the sabkha habitat. They are classified as algal stromatolites (blue green algae or cyanobacteria) and have surface leathery laminations, several centimetres in thickness (Friedman and Krumbien, 1985; Kendall, 1996). These organisms represent a case of unique adaptation to extreme living conditions of temperature and salinity. It was also suggested by some workers (e.g. Friedman and Krumbien, 1985, Alsharhan and Kendall, 2002) that these algal materials may have been an important source rocks for hydrocarbons in the past geologic time of the region. It can be noticed also that mangroves occupy the intertidal zone were seawater is available, but would rarely be able to occupy areas landward into the supratidal zone. These plants are capable of handling the salt influx, they are not capable of living in Sabkhas which present a much more difficult challenge for adaptation and survival to these plants.

The spectral responses of the sabkha's ecosystem were obtained. Figure 3 shows an example of IR and NIR spectral profiles taken from the study area, and the associated captured images in the RGB, visible and near-infrared as well as red is shown in Figures 3-6. Absorption in the blue region islikely due to carotenoids, which absorb maximally in the400-550-nm range (Vincent et al. 1993), whereas absorptionin the red region corresponds to the maximum chlorophyll-aabsorption at 680 nm. Variation in the reflectivity of the scene across different spectral bands gives an important mechanism to understand the features of the scene. The brown color is the inactive algae. This color of this type develops as a result of oxidation. This type has cracks because of drying. The blue green color is associated with mangrove, and is believed to have younger age and favorable environmental conditions for growth.

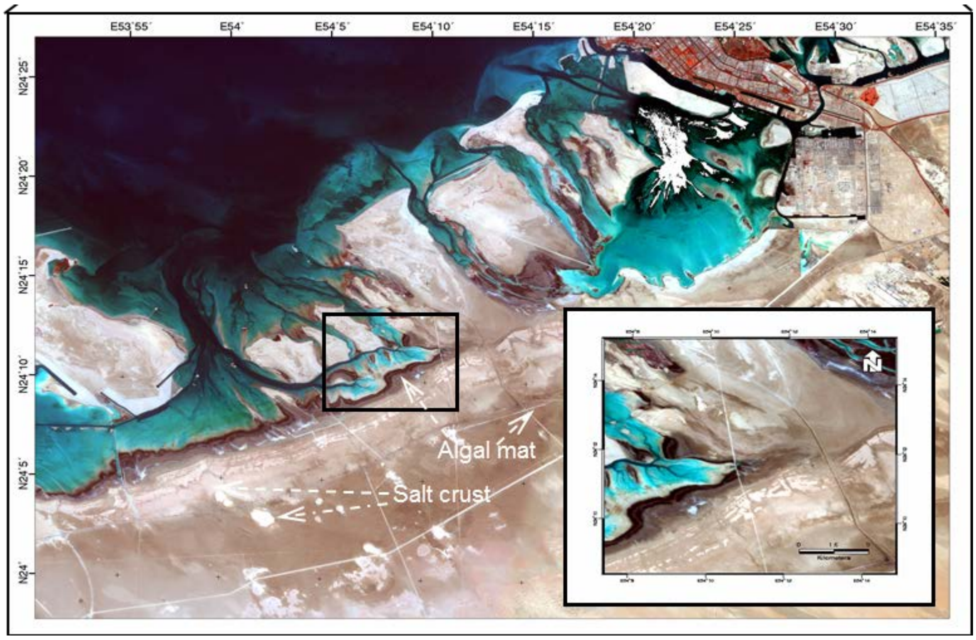

Figure 2a. Landsat image of the study area

Figure 2b. Overview of the study area.

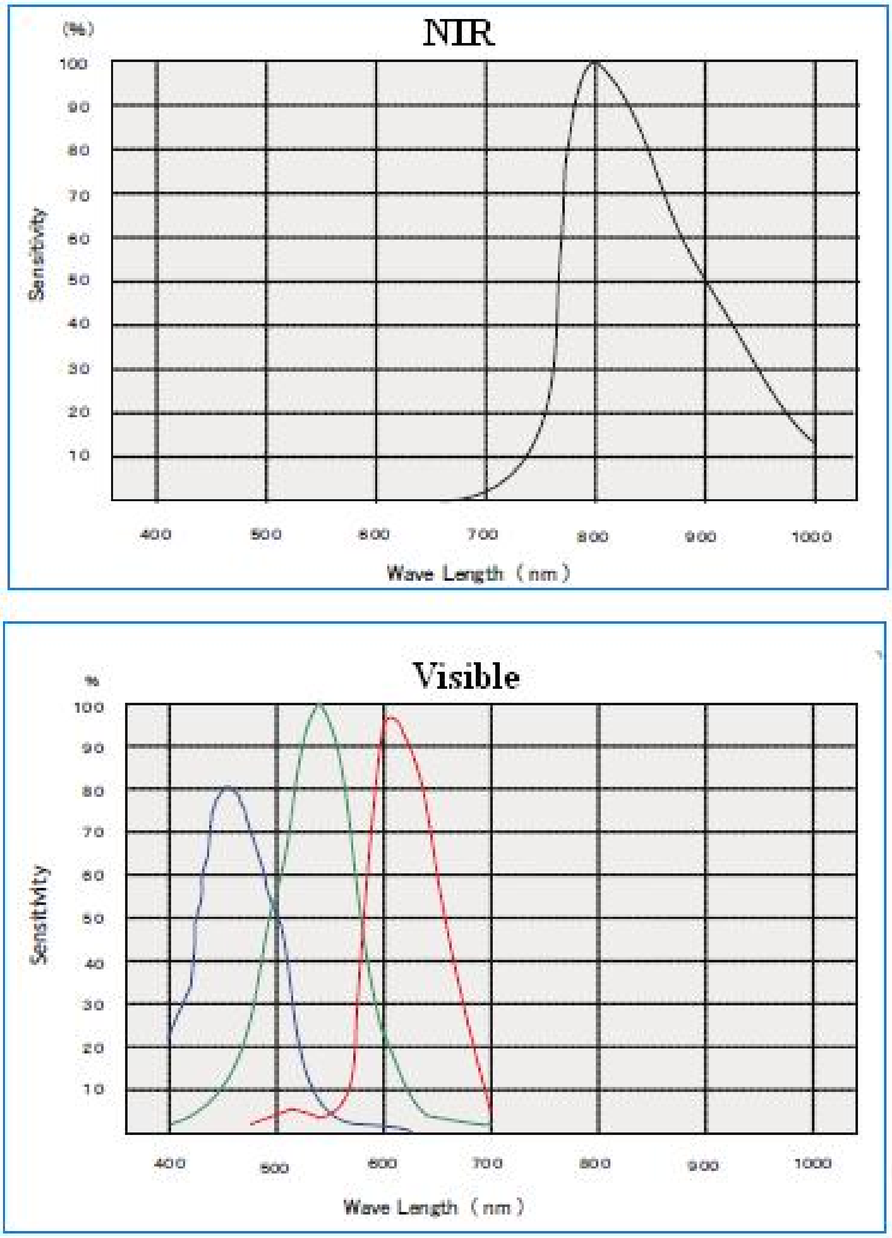

Figure 3. The spectral response of the AD-080GE camera

Figure 4. Original RGB image of the scene

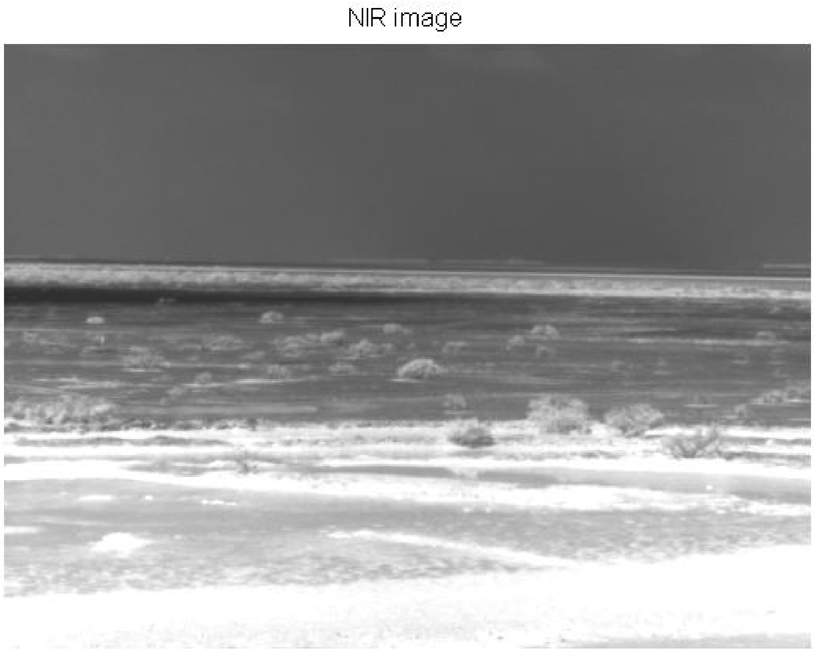

Figure 5. The Near Infrared (NIR) reflectance of the scene

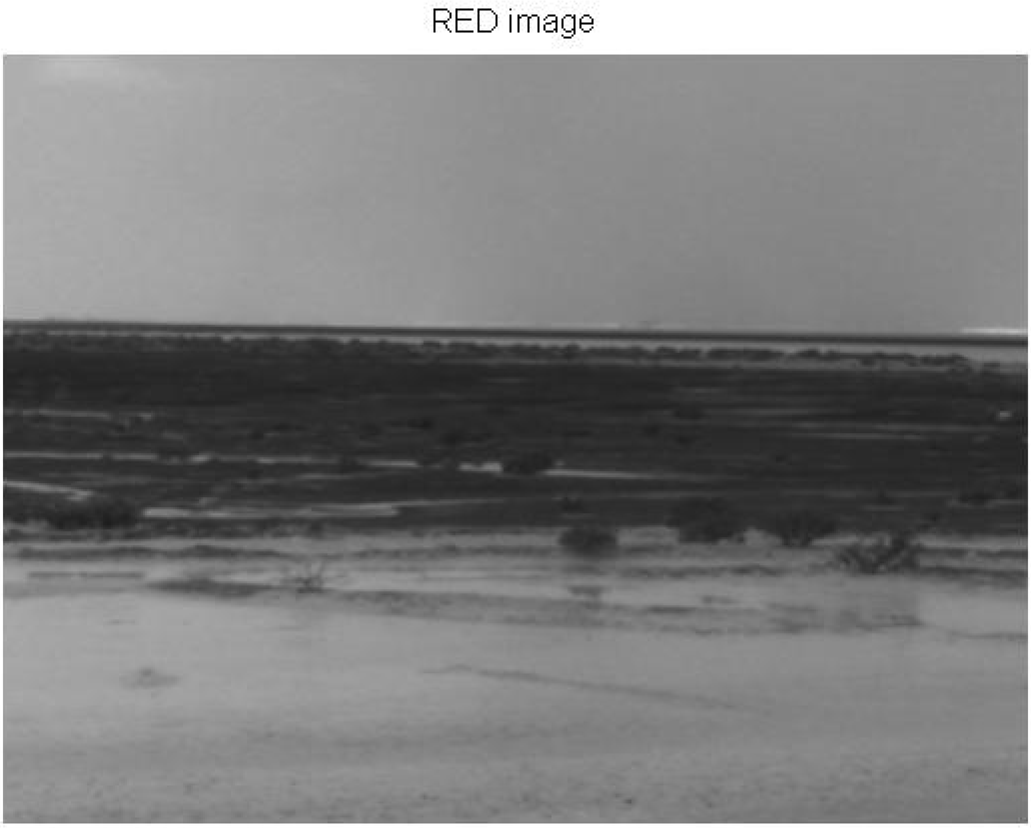

Figure 6. The red reflectance

The NDVI values are represented as a ratio ranging in value from -1 to 1. Where negative values represent water, and values close to zero (-0.1 to 0.1) represent sand, rock or snow and values greater that 0.2 represent vegetations. The NDVI image is shown in Figure 7.

The NDVI values of four points (a, b, c and d) that represent the NDVI of the vegetation, water, algae and sky. The NDVI values are presented in Table 1.

Table1: Calculated NDVI values and associated classes.

Class	NDVI
Vegetation (point a)	0.67
Wetland (point b)	0.07
Algae (point c)	0.45
Sky (point d)	-0.23

As can be noticed low, positive values represent algea (approximately 0.3 to 0.4), while high values indicate well developed trees of the mangrove system. The NDVI values can be correlated to the concentrations of chlorophyll, because it strongly absorbs radiation in the red and blue wavelengths but reflects green wavelengths. The less is the chlorophyll, the less absorption and proportionately more reflection of the red wavelengths. Measuring and monitoring the near-IR (NIR) reflectance is one way to determine how healthy (or unhealthy) the ecosystem may be.

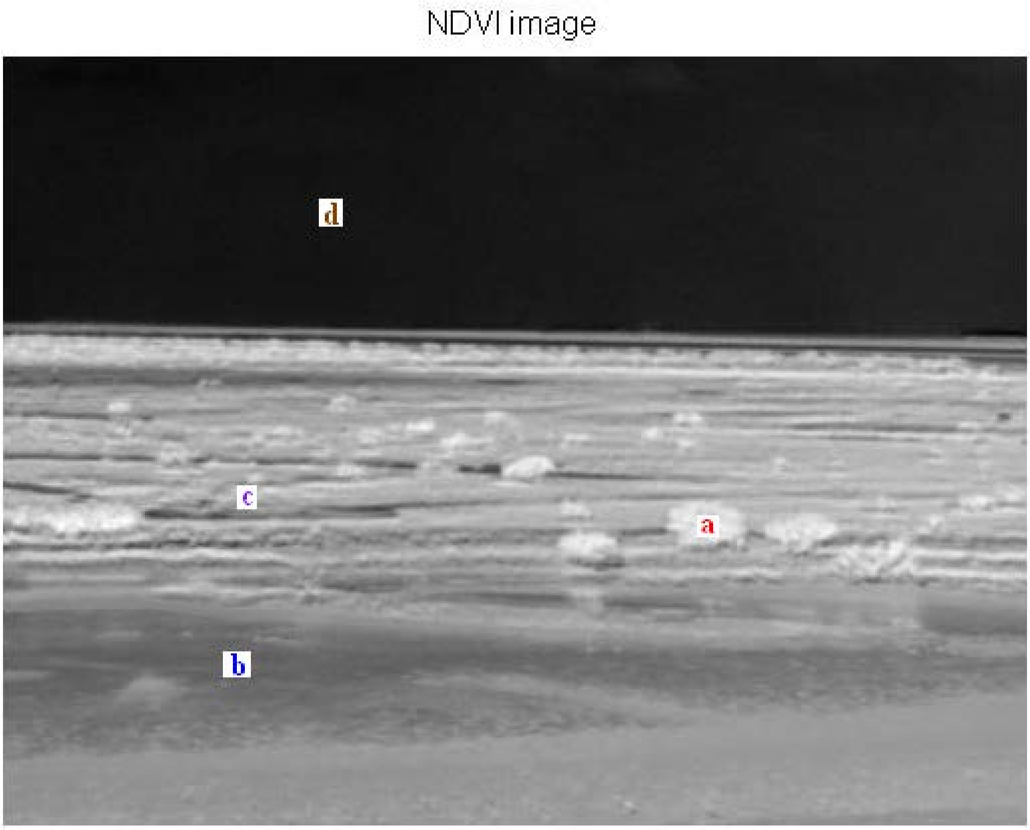

Figure 7. The NDVI image

5. Conclusion

The presented remote sensing data are related to algae characteristics as noted earlier in terms of the the fraction of absorbed portion of the electromagnetic spectrum and the amount of green material. It is believed that remotely sensed algae measurements can give estimates of algae productivity and growth. The applied spectral vegetation indices in the present studies which, transforms red/ green and near-infrared reflectance, have been successfully used as indicators of biomass distribution and changes in the sabkha environment. Results indicated that NDVI was an effective predictor of algal-chlorophyll concentration in our case. The analyses of the images in conjunction with the indications from NDVI show two types of algae active and inactive

ACKNOWLEDGMENT

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Threats to sustainable livestock production in Sudan

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Abstract

Sudan is famous for organic livestock production all over the world. Nevertheless livestock production in Sudan was faced by a lot of obstacles. This paper focuses on identifying these barriers.

Holistic overview of the past, present and future challenges of sustainable was used to identify these constraints. They can be summed up into natural and man –made factors which are interacting together to hinder sustainable management of both animal as well as range resources in Sudan.

Natural factors can be summarized as follows: most of range resources of Sudan in semi-arid and sensitive fragile areas, drought and wet periods, desertification, climate changes, pests and diseases soil types and geomorphologic factors. etc. While man made factors can be grouped in: local culture, conflicts between herders and cultivators, seasonal bush fire, dissolution of native administrations, nomadic tribes coming from neighboring countries or the Sudanese states, poor supervision on range resources, grazing patterns or systems adopted in the country etc.

However, the previously mentioned have resulted in negative and socioeconomic impacts such as loss of herds, migration of herders to the outskirts of the neighbouring urban areas, socio-cultural changes , family disintegration and lack of essential livelihood services , etc. sustainable livestock production can be attained through change in prevailing culture of herders that the number of the animals is the source of political and social prestige , adopting sustainable practices that help in reducing overgrazing and range deterioration, rehabilitation of fire lines and strengthening the role of local institutions for adopting indigenous sustainable practices , etc.

Threats to Sustainable Livestock Production in Sudan

1. Introduction

The area devoted for range and forestry in Sudan is about 61.3% of the total area of the country. The total range lands is about 187 million feddans (feddans=0.42) which is contributed to about 78 million tons compared to 4 million tons provided by irrigated forages, 22 million tons from agro-industrial byproduct and 1.2 million tons from concentrates, totaling 105 million tons per year from the previously mentioned sources of forages in the country (Abu Suwar, 2007).

Rangelands in the Sudan are the main source of feed for domestic and wild animals. Most of the meat consumed locally and for export originate from South Darfur area. Moreover, other animal products such as cheeses, milk and ghee are produced from range animals and assist in pastorals living expenses. It is estimated that about 30 % to 40% of the population of the Sudan are herders who depend primarily on animals to cover their living expenses and 90% of the livestock of the country is owned by them. Besides, rangelands in the Sudan host an important economic tree which is Hashab (*Acacia Senegal)*. It produces Gum Arabic. Furthermore, rangelands contribute to fuel wood and building materials provision (Ibid, 2007).

. II **Paper Objective**

to identify the threats of sustainable livestock production in Sudan and their environmental and Socioeconomic impacts,

III. **Pastrolasim in Sudan**

According to Abu Suwar (2007) Pastoralism as practiced in Sudan is of three types:

1) **Pastoral nomadism:**

It is the regular movement of people, whole families, with their animals in search for pasture and water. Pasture is often discontinuous and is connected with accessibility. Nomads do not generally have permanent houses and live in tents. However, each group has its own and exclusive migratory routes and rights of residence and exploitation over a certain territory referred to as Dar (Dar=homeland). They kept their capital mainly in the form of animals.

Nomads move with their herds according to seasonal variation in climate. They get their food from their animals as milk or meat. Nomadic herders have no permanent dwelling and have few material possessions as they are constantly on move.

2) Semi-nomadism:

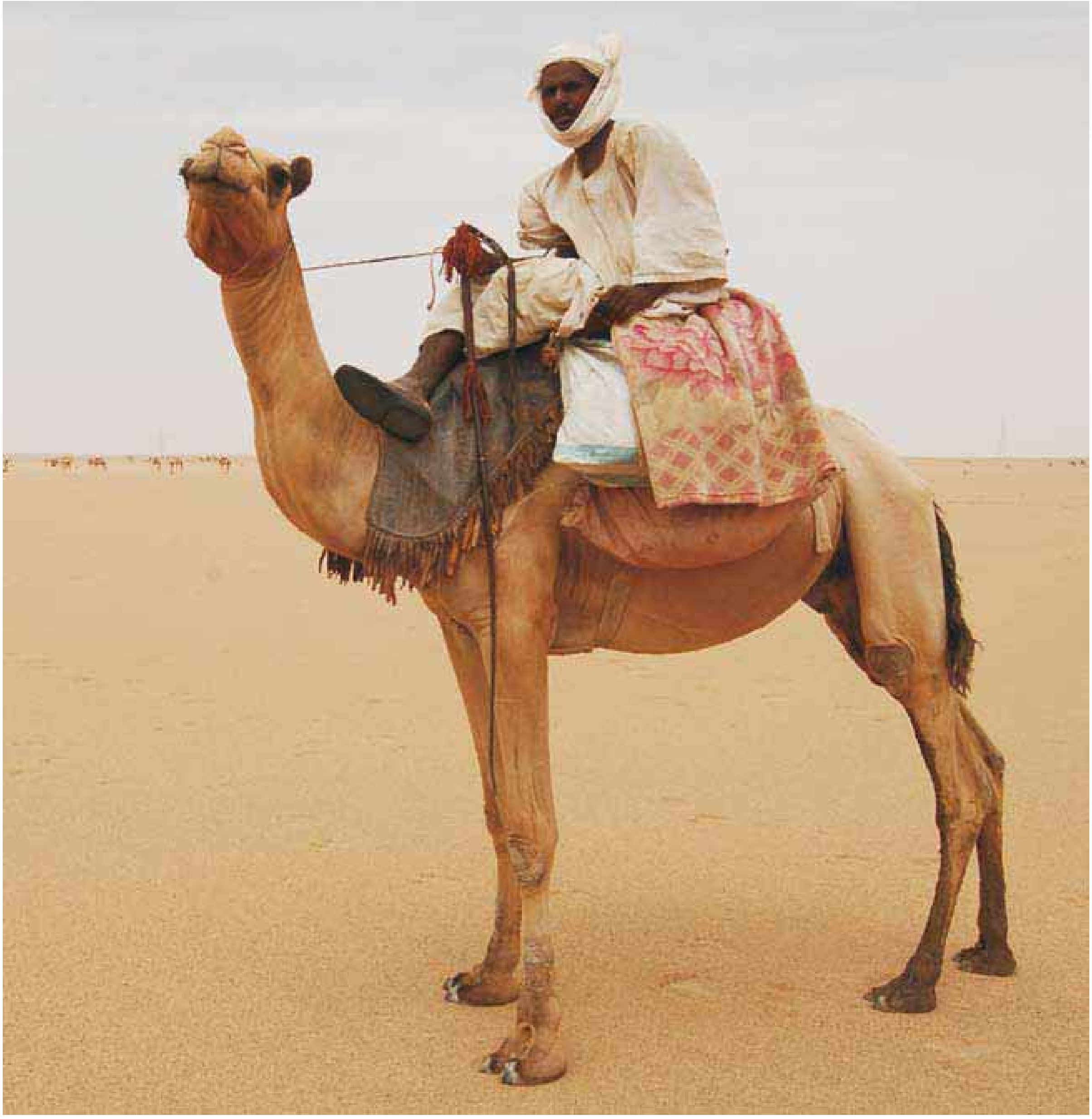
It is a situation where part of the family is left in the Dar while the remainders move about with livestock in search of good pasture and water. Those who left in the Dar are engaged in a variety of occupation, but the most dominant among them is cultivation.

3) Sedentary Pastoralists:

It is a highly developed form of pastoralism which is practiced by sedentary cultures whose major economic activity is agriculture. The animals' movement is generally undertaken from a permanent base.

Taking the above mentioned types in consideration, a nomad is defined as an animal breeder who is continuously moving with his herd looking after pasture and water and/or avoiding mud or flies. Pastoral nomadism is, therefore, not just a haphazard wandering but it is a well- established pattern of life. It is a systematic, well-organized way of life geared to the well-being of its people and their animals. It is a rational adaption of human life to the environment.

In keeping the variation in the climatic condition which may have adverse impact on animals, nomads are well adapted and better use the fluctuating forage supplies or escaping drought and avoiding biting flies and excessive mud during the rainy season. Nomadism as system of livestock production is so far responsible for preserving livestock in Sudan from extinction. Nevertheless nomads suffer from inability and their families to receive essential services such as health and education and are have no access to other social services provided by the government to the people who have a permanent residence.



A camel Herder from North Sudan

IV. Causes of unsustainable livestock production in Sudan

The area of rangeland in Sudan is estimated at about 100 million hectares. Livestock is estimated to be over 120 millions composed of cattle, sheep and goats and camels which are kept under both nomadic and sedentary traditional pastoral system. Livestock accounts for about 47 % of agricultural GDP and 22 % of the total GDP in year 2000. It is an important sector that provides a source of livelihood for huge segment of the population. It is also an important foreign exchange earner. Livestock production comprises pastoralism, sedentary and semi-sedentary and commercial fattening and dairy.

These causes can be presented as follows:

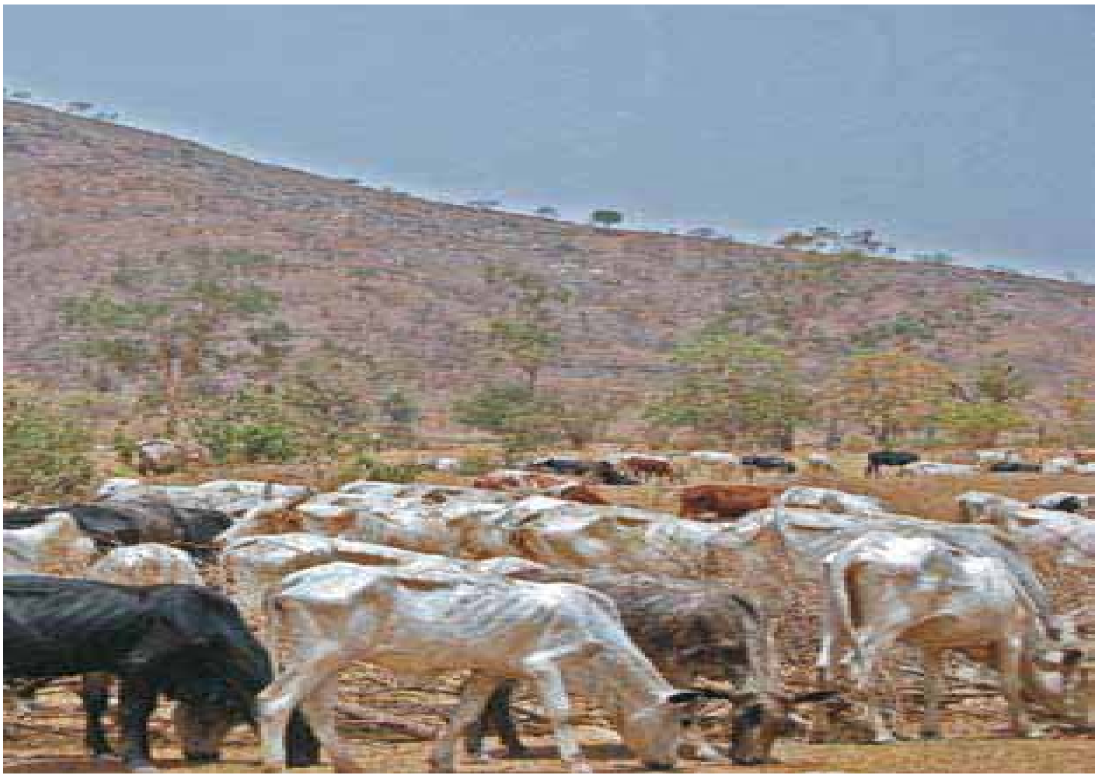
1. **Continuous increase in animals' number:**

there has been an increase in the livestock population over the past few years due to a number of factors which include: inherited culture that the number of animals is a source of political power and social prestige, improvement in veterinary services, low take off of animal or poor sale resulted from poor transportation, absence of proper marketing channels and the nomadic life of the majority of the herders, vast improvement in animal health care, which had drastically reduced outbreaks of epidemics and small rate of take-off for export or national consumption, high local taxes have also contribute to this increase. The table below show this increase:

Table shows livestock population for the period 1998-2000 (in million)

Animal type	1998	1999	2000
Cattle	35	36	37
Sheep	42	45	46
Goats	36	37	38
Camels	3	3	3
Total	116	121	124

The increase in umber resulted in overgrazing which led to environmental degradation



Cattle in poor condition on overgrazed land near El Geneina, Western Darfur. Intense competition over declining natural resources is a contributing cause of the ongoing conflict in the region.

In addition, an explosive growth in livestock numbers – from 28.6 million in 1961 to 134.6 million in 2004 – has resulted in widespread degradation of the rangelands. Inadequate rural land tenure, finally, is an underlying cause of many environmental problems and a major obstacle to sustainable land use, as farmers have little incentive to invest in and protect natural resources.

2. **Land degradation** through over-use or misuse, population growth or displacement disadvantageous changes I land tenure, cause lasting damages to the people, the animals and environment.

3. Insecurity of land ownership, the government of the Sudan owns all lands in Sudan but it does not exercise any effective control over its use. At the same time the government has not fully the customary use of land by different groups of people. The communal use of land particularly in rural Sudan is a very strong institution.

3. **Expansion of Mechanized agriculture at the expense of traditional grazing sites or range lands:**

The horizontal expansion of agriculture into areas that were previously either rangeland or forest has been a well recognized trend for the last four decades. The northwards expansion of rain-fed agriculture into marginal areas historically only used for grazing has been particularly damaging. Three examples from the recent UNEP-ICRAF study of land use changes illustrate a major reduction in rangeland areas due to expanding agriculture:

• In Ed Damazin, Blue Nile state, agricultural land (mainly mechanized), increased from 42 to 77 percent between 1972 and 1999, while rangeland effectively disappeared, dropping from 8.3 to 0.1 percent; • In the El Obeid region of Northern Kordofan, rain-fed agricultural land increased by 57.6 percent between 1973 and 1999, while rangeland decreased by 33.8 percent and wooded pasture by 27 percent; and

• In the Um Chelluta region of Southern Darfur, rain-fed agricultural land increased by 138 percent between 1973 and 2000, while rangeland and closed woodland decreased by 56 and 32 percent, respectively.

In addition to the loss of grazing land, agricultural expansion has also blocked livestock migratory routes between many of the widely separated dry and wet season pastures, and between the herds and daily watering points. A further complication is that sedentary farmers are increasingly raising their own livestock, and are hence less willing to give grazing rights to nomads in transit.

In many parts of Sudan particularly Eastern, Central and western arts, the expansion of mechanized agriculture is the main cause, as vast lacks of natural pasture grazing has been converted to agricultural ecosystems without replacement of their lost grazing biomass. The traditional corridors of animal grazing movement which were synchronized with pasture productivity have been disrupted as a result . This in turn led to overcrowding and overgrazing and resulted in conflicts between herders and cultivators, blockage of the road to water points and eating of animals on the grown crops

<u>The impact of the expansion of cultivation at the expense of herding or livestock production in Sudan:</u>

a) The net result – disappearing livelihoods for dry lands and pastoral societies

The clear trend that emerges when these various elements are pieced together is that of a significant long-term increase in livestock density on rangelands that are reducing in total area, accessibility and quality. In environmental terms, the observed net result is overgrazing and land degradation. In social terms, the reported consequence for pastoralist societies is an effectively permanent loss of livelihoods and entrenched poverty.

Pastoralist societies in Sudan have always been relatively vulnerable to losing their livelihoods due to erratic rainfall, but the above-noted combination of factors has propelled many pastoralists into a negative spiral of poverty, displacement, and in the worst cases, conflict. Their coping strategies or the impact) include:

1. Abandoning pastoralism as a livelihood in favour of sedentary agriculture, or displacement to cities;
2. Increasing or varying the extent of annual herd movements where possible, with a general trend towards a permanently more southerly migration;
3. Maximizing herd sizes as an insurance measure (assisted by the provision of water points and veterinary services);
4. Changing herd composition, replacing camels by small animals, mainly sheep, in response to the curtailment of long-distance migration;
5. Competing directly with other grazers for preferred areas of higher productivity (**entailing a conflict risk**);
6. Moving and grazing livestock on cropland without consent (**entailing a conflict risk**); and
7. Reducing competition by forcing other pastoralists and agriculturalists off previously Conflict Scenario) shared land (as a last resort).

Variations of all of these strategies can be observed throughout Sudan, particularly in the drier regions. Displaced populations settle on the outskirts of existing towns, as seen here in El Fasher, Northern Darfur, where the new settlement is distinguished by white plastic sheeting. These new arrivals add to the environmental burden on the surrounding desert environment

b) The southward migration of camel herders into the Nuba mountains and subsequent resource competition

The Nuba mountains region in Southern Kordofan provides an example of the increase in natural resource competition and local conflict those results from the combination of agricultural expansion, land degradation and the southward migration of pastoralists.
At the start of the civil war in the 1980s, cattle-herding pastoralists from the Hawazma Baggara tribe started penetrating deeper into the Nuba mountains in search of water and pasture for their cattle, due to the loss of grazing land to mechanized agriculture and drought. The rivalry that ensued with the indigenous Nuba tribe, who practised a combination of sedentary farming and cattle-rearing, contributed to the outbreak of large-scale armed conflict. Meanwhile, as some of the dry season pastures around Talodi were off-limits during the conflict years, the Hawazma had to remain in their wet season grazing lands in Northern Kordofan, exerting greater pressure on the vegetation there.
In 2006, UNEP observed the return of Hawazma Baggara to their former grazing camps in conflict zones in Southern Kordofan, for example near Atmoor. UNEP also witnessed the presence of the camel-herding Shanabla tribe in the midst of thick woodland savannah at El Tooj (now reportedly reaching up to lakes Keilak and Abiad).
This new southward migration of camel herders constitutes an indicator of livestock overcrowding and rangeland degradation in Northern Kordofan, and is a harbinger of further conflict with the Nuba. At Farandala in SPLM-controlled territory, the Nuba expressed concern over the widespread mutilation of trees due to heavy lopping by the Shanabla to feed theircamels, and warned of ‘restarting the war’ if this did not cease. Camel herders from the Shanabla tribe at a water point in El Tooj, Southern Kordofan. The southward migration of camel herders is a harbinger of renewed conflict in the Nuba mountains.

c) Conclusions on the role of environmental issues in conflicts over rangeland and rain-fed agricultural land:

Pastoralist societies have been at the centre of local conflicts in Sudan throughout recorded history. The most significant problems have occurred and continue to occur in the drier central regions, which are also the regions with the largest livestock populations, and under the most severe environmental stress. As there are many factors in play – most of which are not related to the environment – land degradation does not appear to be the dominant causative factor in local conflicts. It is, however, a very important element, which is growing in significance and is a critical issue for the long-term resolution of the Darfur crisis. The key cause for concern is the historical, ongoing and forecast shrinkage **and** degradation of remaining rangelands in the northern part of the Sahel belt.

4. Deforestation and decrease of perennial grasses due to overgrazing and spread of annual and evasive species.

Deforestation occurs due to many factors the most important nes are: expansion of mechanized farming on natural forests and traditional rangelands. Moreover nomads are used to destroy annually millions of Acacia trees for cocking and warming purposes.

Deforestation in Sudan is estimated to be occurring at a rate of over 0.84 percent per annum at the national level and 1.87 percent per annum in UNEP case study areas. It is driven principally by energy needs and agricultural clearance. Between 1990 and 2005, the country lost 11.6 percent of its forest cover, or approximately 8,835,000 hectares. At the regional level, two-thirds of the forests in north, central and eastern Sudan disappeared between 1972 and 2001. In Darfur, a third of the forest cover was lost between 1973 and 2006. Southern Sudan is estimated to have lost 40 percent of its forests since independence and deforestation is ongoing, particularly around major towns. Extrapolation of deforestation rates indicate that forest cover could reduce by over 10 percent per decade. In areas under extreme pressure, UNEP estimates that total loss could occur within the next 10 years.

These negative trends demonstrate that this valuable resource upon which the rural population and a large part of the urban population depend completely for energy is seriously threatened. The growing use of fuel wood for brick-making in all parts of Sudan is an additional cause for concern. In Darfur, for instance, brick-making provides a livelihood for many IDP camp residents, but also contributes to severe localized deforestation. If it were properly managed, however, the forestry sector could represent a significant opportunity for economic development and sustainable north-south trade.

5. Fire and fire line maintenance:

Annually fire destroys 47 % of the total rangelands of the country. In the past and prior the dissolution of native administration in 1970 regular maintenance of fire lines were used to be done under the supervision of these institutions. This had resulted in annual fires destroying the rangelands.

6. Dissolution of native institution :

Before this institutions were not responsible for fire line maintenance but also regulating the use of the available forage and water resources among various nomadic tribes and local herders as well as solving the conflicts between herders and between herders and farmers. Therefore the uses of range lands are sustainable and secured

7. Micro- and macroclimatic changes (practically continuous Sahel drought since 1967 and 1980; diminishing and erratic rainfall and accelerating desertification doubling of livestock within 20 years; and deforestation on massive scales

Desertification and regional climate change: contributing to poverty and conflict

An estimated 50 to 200 km southward shift of the boundary between semi-desert and desert has occurred since rainfall and vegetation records were first held in the 1930s. This boundary is expected to continue to move southwards due to declining precipitation. The remaining semi-desert and low rainfall savannah on sand, which represent some 25 percent of Sudan’s agricultural land, are at considerable risk of further desertification. This is forecast to lead to a significant drop (approximately 20 percent) in food production.

In addition, there is mounting evidence that the decline in precipitation due to regional climate change has been a significant stress factor on pastoralist societies – particularly in Darfur and Kordofan – and has thereby contributed to conflict.

8. Oil Exploration and its impact on herders and their herds:

* Most of oil exploration areas in Sudan had confined to the majority of rangelands • in South and West Kordofan. They present about more than 80% of the area of these two states.

* Traditional animal migratory routes had been blocked by the construction of new roads.

* Rangelands had polluted by petroleum wastes that are hazardous to herds.

* Cattle in Eastern Sudan were prohibited from gazing nearer to Bashayer oil exporting ports

* Periodic maintenance of animal migratory routes is difficult because of the continuation in exporting oil.

* local inhabitants of Abu Jabara fields complained from the contamination of their drinking water sources from the wastewater resulted from oil exploration.

Causes of unsustainable livestock production in Sudan

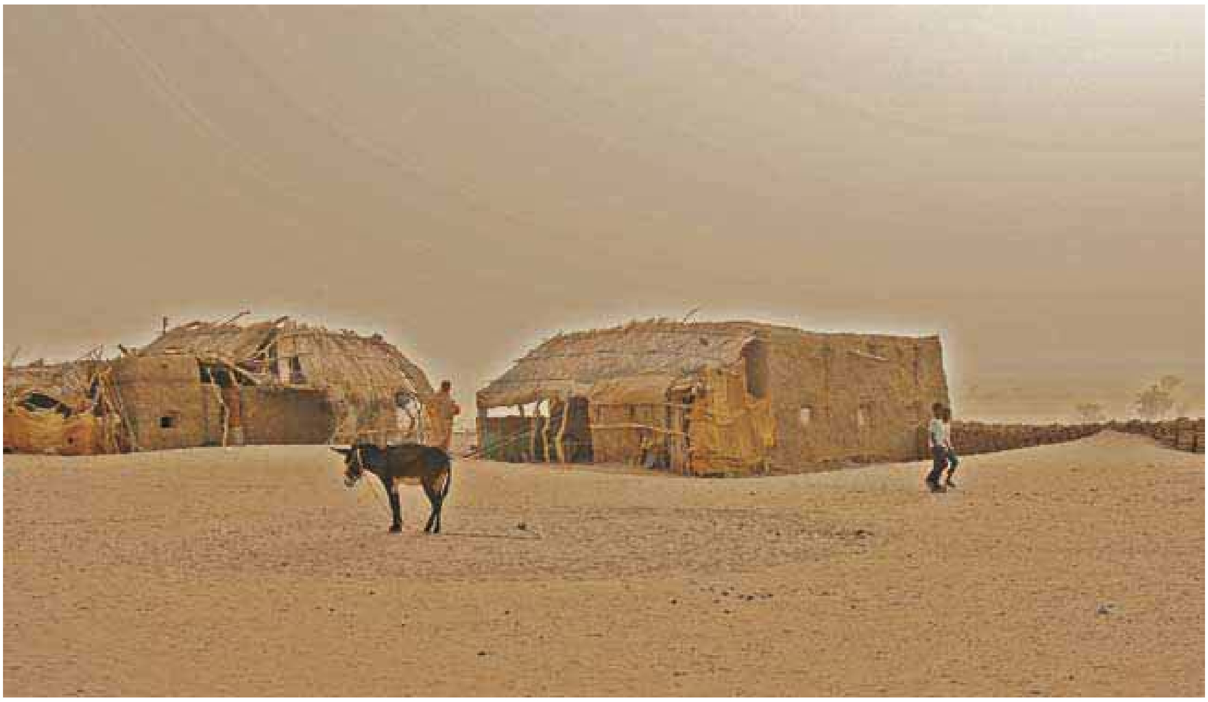
V. The Socio-economic Impacts of above mentioned threats:

1, Nomadism in its way to disappear in Eastern and Central Sudan (e.g. in Butana area)

2. Small ruminant animals are now dominant at the expense of cattle

3. Drought resulted in loss of herds and inability of nomads to restock their herds to the pre-drought levels.

4. Some nomads work nowadays as causal agricultural labour while others migrated to the outskirts of the neighbouring urban centers. This has resulted in sociocultural transformation of hose displaced people who work in marginal jobs and living in slums receiving no social services or the basic needs for sustainable living conditions.



The most serious and common natural disaster facing the population of Sudan is drought. Rural communities such as this village in Khartoum state have faced waves of drought since the 1970s, which have exacerbated rural poverty and precipitated large-scale displacement to the northern cities

V.I. **Recommendations:**

Sustainable livestock production in Sudan can be attained through :

1. Change in prevailing culture of herders that the number of the animals is the source of political and social prestige,

2. Adopting sustainable practices that help in reducing overgrazing and range deterioration,

3. Rehabilitation of fire lines

3 strengthening the role of local institutions

4. Adopting indigenous sustainable practices

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2- Participating a large number of large international environmental conferences and was selected as a keynotes in more than three conferences.

3- Select as one of the UNEP regional consultants for selecting the priority issues in the adopting MDGs. in Africa, GEO- 5, UNEP, Nairobi, Kenya (2011).

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Towards sustainable mobility: User experiences and views on electric vehicles

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Electric vehicles (EVs) are promoted as an important means to make transport more sustainable. Previous research indicates that the use of EVs could substantially reduce greenhouse gas emissions, local air pollution and noise caused by the traffic. In addition, electric traffic could reduce oil dependency. For EVs to become widespread, consumers need to be ready to accept them for daily use. This requires that EVs are able to offer consumers some real advantages compared to traditional vehicles. (e.g. Hoogma et al., 2002; Kurani et al., 2008; Jansson, 2011; Graham-Rowe et al., 2012). However, so far, consumers have not been eager to adopt and use EVs. Therefore, it is important to examine the consumer opinions on EVs and electric traffic to find out the crucial factors that would encourage them to become EV users.

This paper explores EV user experiences and views on the introduction, use and impacts of the EVs, as well as the development needs of services in electric traffic. We look into factors that, on the one hand, motivate consumers to acquire EVs, and, on the other hand, have a negative effect on consumer acceptance. We are also interested in changes in car usage and other everyday practices following the introduction of EVs, and what the emerging practices require from the car drivers and the whole operational environment. The paper is part of our ongoing user study that aims to increase understanding on the possibilities and challenges of electric mobility from the perspective of consumers and users. The user study is linked to a Finnish project that promotes electric traffic in Finland, and utilizes the test-bed developed by the project, including a fleet of EVs acquired by the project.

The paper is based on a qualitative analysis of responses of 16 Finnish EV users involved in our study. User feedback was collected using semi-structured interviews from the participants, who used battery electric vehicles (BEVs) or plug-in hybrid vehicles (PHEVs). Half of the participants used company EVs that were involved in the test-bed of the above-mentioned Finnish project, and the others were using self-owned EVs. The theoretical framework used in the study is the theory of social practices (Shove et al., 2012).

The research results indicate that users see EVs in a positive light and as real alternatives to traditional vehicles. EVs are considered an attractive means of transport because of practical factors, such as low emissions, low running costs and convenience. In addition, they are associated with symbolic and emotional meanings that are considered a source of positive social identity and pleasure. Examples of such meanings are protection of the environment and adoption of the latest technology. On the other hand, there are still some disadvantages in EVs compared with the conventional vehicles that restrict, or at least delay, the adoption of EVs. The higher prices of EVs and insufficient infrastructure for recharging are seen the main concerns for consumers.

The first buyers and users of EVs in Finland seem to be consumers who are positively inclined towards environmental protection or new technologies. For EVs to achieve a wider popularity among consumers, the electric traffic infrastructure and EVs need to be developed in such a way that they would better meet the needs of different types of consumers.

Keywords: Sustainable mobility, electric vehicles, consumer behaviour, practice theory

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TWENTY YEARS OF LAND USE AND LAND COVER CHANGE OF KALAW CHAUNG SUB-WATERSHED OF INLE LAKE IN MYAMMAR

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Abstract

This study was focused on the changes of land use and land cover (LULC) of the Kalaw Chaung Subwatershed of Inle Lake which is located in the Nyaung Shwe Township, Taunggyi District, Southern Shan State, Myanmar. The study area covered about 485.42 square kilometers of the whole watershed of Inle Lake. The objectives of this research are to analyze and understand LULC patterns of the study area and to analyze LULC magnitude and trend of changes between 1990, 2000 and 2010. Geographic Information System (GIS) and Remote Sensing (RS) provide as useful tools in the investigation of LULC patterns and the detection of LULC changes over space and time. All Landsat images (1990 TM, 2000 ETM and 2010 ETM) are rectified and registered in Universal Transverse Mercator (UTM) zone 47 N. Unsupervised and Supervised classification system was carried out to classify the images in different land use and land cover categories. The classification has identified five land use classes: Agriculture land, Close forest, Open forest, Scrub grass land and Water body. According to the study of this research, there were major changes in open forest and agriculture land. Open forest had been reduced up to 39.64 % between year 1990 and 2000 and Scrub grass land had been increased up to 35.80%. On the other hand, during 2000 and 2010, agriculture area was highly increased up to 50.44 % and open forest was decreased up to 21.51 % due to slash burns or shifting cultivation and the pressure of population.

Keywords: Land Use and Land Cover (LULC), Geographic Information System (GIS), Remote Sensing (RS)

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1. Introduction

Land use and land cover change (LULC) is one of the major phenomena of global environmental change and vital to the sustainable development debate. For example, in the past two decades between 1980-2000 periods, more than half of forest area in the tropics has been converted to agricultural land due to globalization process and its economic pressures (Lambin and Mayfroidt 2011). These changes have severe impacts on a broad range of environmental and landscape, characteristics including the quality of water, land and air resources, ecosystem processes and function, and the climate system itself through greenhouse gas fluxes and surface. According to the measurement of green house gas (GHG) emissions, 18 percents of total green house gases come from land use/ land and land cover changes by deforestation (World Band 2008)

Land use and land cover are two chief constituents describing the terrestrial environment in the relationship between natural processes and anthropogenic intervention activities. In recent decades, the research on land use and land cover changes has become a well-known research topic, since land use/ land cover change has been recognized as one of the most important factors of environmental modification (Mendoza et al., 2011). There are many meanings of the terms “Land use” and “Land cover” that often used interchangeable but their actual meanings are quite distinct. In general, Land use refers to human activities that take place on the earth’s surface: how the land is being used; such as residential housing, agricultural cropping or industry. On the other hand, Land cover refers to the natural or manmade physical properties of the land surface (Kuldeep & Kamlesh, 2011).

Land use-land cover change analysis provides information to planners and policy makers on what should be done to have reasonable and balanced development that will be sustainable and eco-friendly. The knowledge on land use and land cover is therefore vital for many planning and management activities associated with the surface of the earth.

The LULC analysis presented in this paper is based on the statistics extracted from change detection technique of the three temporal Landsat TM & ETM images (1990, 2000, 2010) of the Kalaw Chaung Sub-watershed of Inle Lake, Myanmar together with analysis of Geographic Information System (GIS).

The spatial information technologies such as Geographic Information Systems, Remote Sensing and Global Position Systems are useful for monitoring and inventorying changes and predictions of LULC based on different practices and management plan. Remote Sensing and GIS technique is quick and efficient approach in the classification and mapping of land use/ land cover changes over difference spatial and temporal scales (Abbas 2012).

2. Objective

The main objective of the study is to assess land use-land cover changes in the Kalaw Chaung Sub-watershed of Inle Lake, Myanmar. The specific objectives are:

(i). to analyze and understand LULC patterns of the study area in years 1990, 2000 and 2010 using multi-date satellite imageries.

(ii). to analyze LULC magnitude and trend of changes between 1990, 2000 and 2010.

3. Methodology

3.1 Study Area

Inle Lake, the second largest lake, is located in theNyaung-shwe Township, Taunggyi District, Southern Shan State in Myanmar, and extends from approximately 20º 15 ´ to 20º 45´ N latitude and 96º 49´ to 96 º 48´ E longitude. The Lake is one of the main tourist attractions in Myanmar because there are many interesting recreational activities such as beautiful landscape, pleasant weather condition, floating garden, floating market, leg rowing, PhaungDawOo Pagoda festival, traditional handicraft. Form ecological perspective, the lake is home to wetland species such as migratory and residential birds and Inle Carp locally called Nga-Phane.The lake is impacted by many factors including sedimentation from deforestation, forest and land degradation, soil erosion, land use changes in the watershed areas. The lake bed is comprised of fine silt deposited by the surrounding streams which flow through the plateau's limestone. Thirty streams flow into the lake. There are four main streams flowing into Inle Lake such as Nam Let Chaung, Negya (Yebei) Chaung, Kalaw Chaung and Nan Pilu (Balu) Chaung. The lake has one outlet which flows to the south entering the Thanlwin River. The location map of study area was shown in figure 3.1.

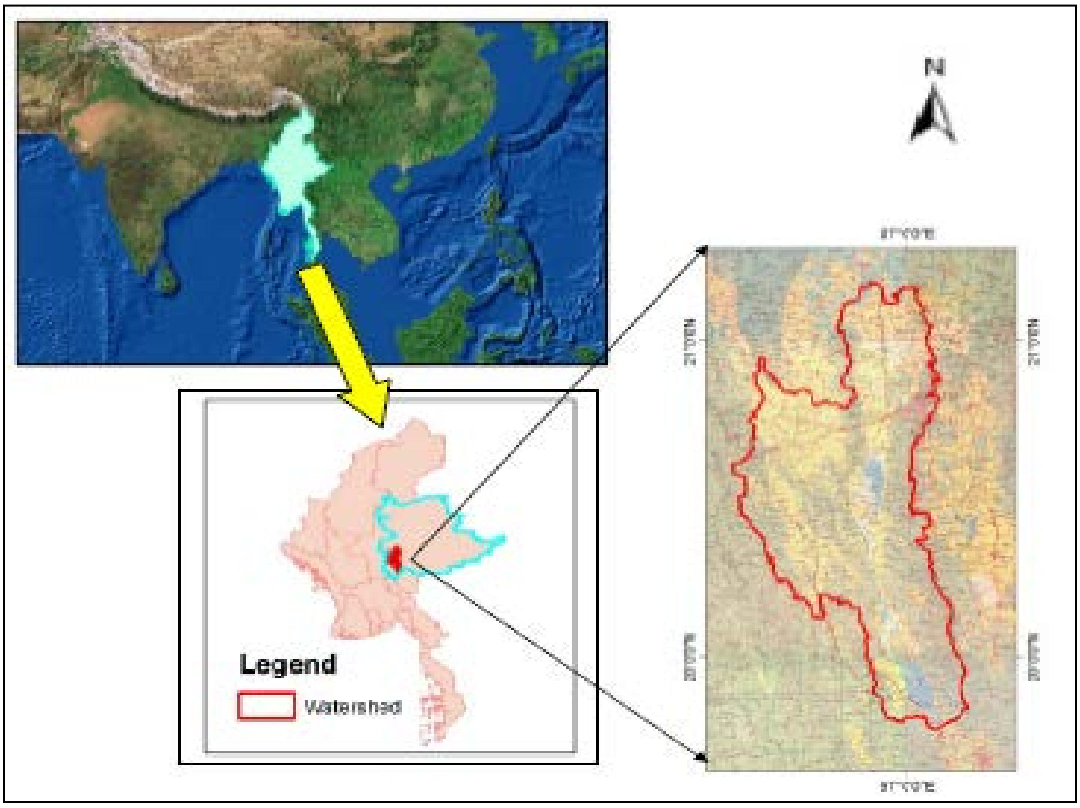


Figure 3.1 Location Map of the Study Area, Background: Topographic Map (1:250,000)

3.2 Method for Image Classification, Land Use Map and Change Detection

The processing flow of image classification, land use mapping and land cover change detection is showing in Figure 3.2. Four main steps are included as follow:

(i) Data preprocessing

(ii) Image classification

(iii) Land use/ land cover map preparation and

(iv) Quantify land use/ land cover changes.

The preprocessing step includes image registration and data normalization. Unsupervised classification, ground truth data collection, supervises classification and verifies accuracy was carried out in image classification step. Then classified images are segmented into separate layers of each class. When map generation was finished, land use land cover map of 1990, 2000 and 2010 were generated. Land use land cover changed was quantified follow the procedure of geo-processing (intersection, union and erase).

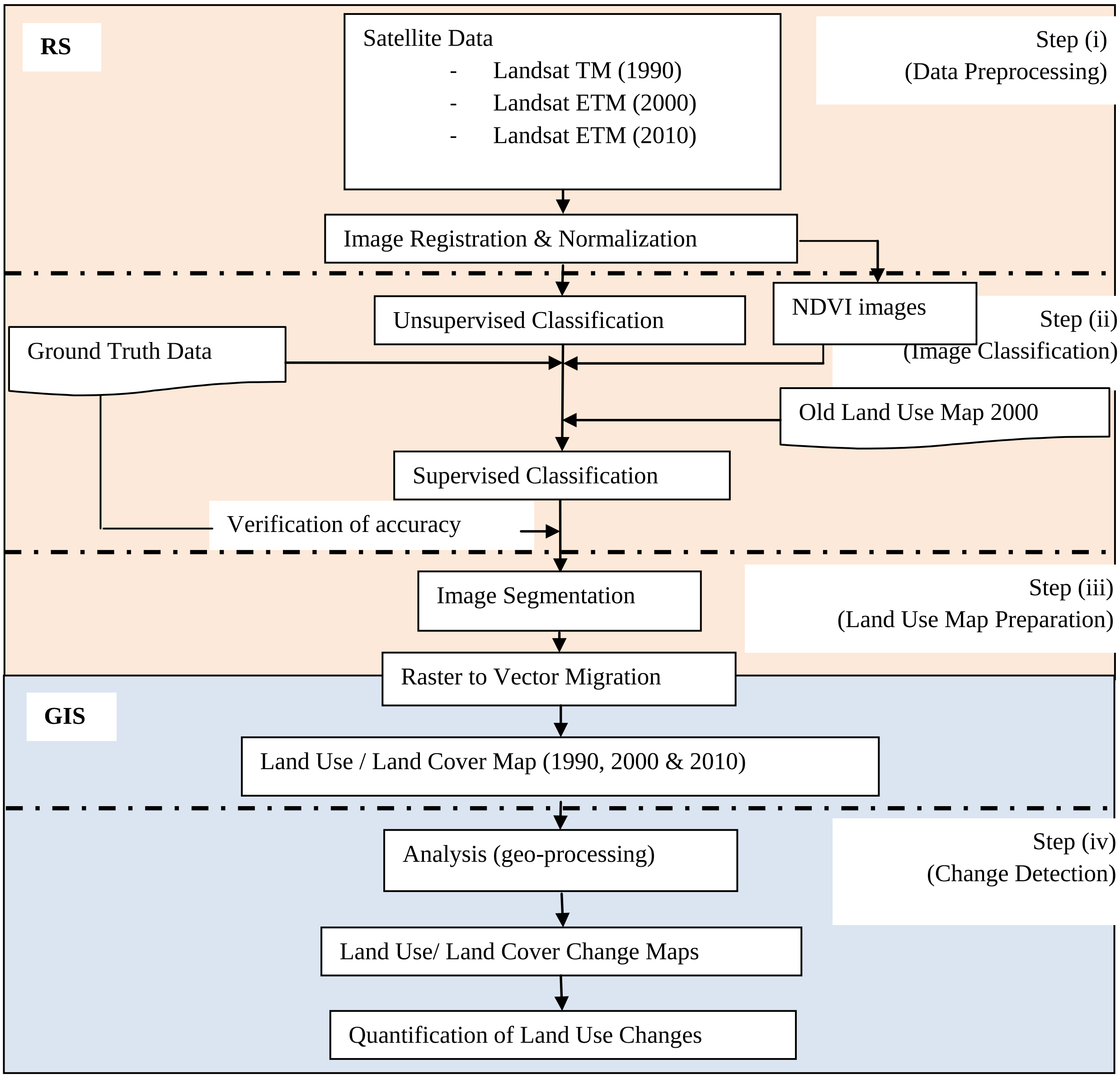


Figure 3.2 Flow Chart of Change Detection

3.3 Data Preprocessing

3.3.1 Image Registration

Image registration was performed registering Landsat TM 1990, Landsat ETM 2000 and Landsat ETM 2010 images based on 1:50,000 scale topographic map. The images were resembled to 30m by 30m pixels using a Nearest Neighbor Resampling algorithm with a RST (rotation, scale, and transformation) first-order polynomial. The number of ground control points (GCPs) used for the registration varies by images, and the root mean square error (RMSE) of the registration process is shown in Table 3.1.

Table 3.1. Ground Control Point Table

Acquisition date	Image	Number of GCP for Registration	Geometric Registration RMSE (pixel)
132-45 (path-row) taken March02,1990	Landsat TM	15	± 0.54
132-45 (path-row) taken March 02,2000	Landsat ETM	17	± 0.69
132-45(path-row) taken March 05, 2010	Landsat ETM	19	± 0.71

GCP: Ground Control Points; RMSE: Root Mean Square Error of x, y coordinates

3.3.2 Conversion from DN to Reflectance Value

Converting from DN (Digital Number) to reflectance was done because changing sun illumination geometry strongly affects DN. A transformation based on reflectance is more appropriate for regional application where atmospheric correction is not feasible. (Kauth and Thomas, 1976). Raw digital number was converted to reflectance using the formula describing in Landsat 7 Science Data Users Handbook (Irish, 2000). Firstly, DN value was converted into radiance using the following equation 3.1.

$$L\lambda = \left(L\max,\lambda - L\max\lambda\right)/\,255 * DN + L\min,\lambda \qquad \text{Equation 3.1}$$

And then conversion of radiance into reflectance was carried out by using the equation 3.2, 3.3 and 3.4.

$$\rho\lambda = \frac{\pi \cdot L\lambda \cdot d^2}{E\lambda \cdot \cos\theta} \qquad \text{Equation 3.2}$$

$$d = 1.00011 + 0.034221\cos x + 0.00128\sin x + 0.000719\cos 2x + 0.000077\sin 2x$$

Equation 3.3

$$x = 2\pi(DOY)/365 \qquad \text{Equation 3.4}$$

Where, $\rho\lambda$ = unitless planetary reflectance

$L\lambda$ = spectral radiance at the sensor's aperture

d = earth- sun distance in astronomical units

$E\lambda$ = mean solar exoatmospheric irradiances

θ = solar zenith angle in degrees

3.4 Classification Process

3.4.1 Define Land Use Classes

Land use classes are assigned based on existing land use 2000 data (Table 3.2).

Table 3.2 Land Use Land Cover Classes (source: existing land use map 2000)

No.	Land cover name	Description
1.	Water body	Lakes, Reservoir, river
2.	Agriculture	Paddy field, crop filed, swidden agriculture (slash & burn), orchard, village garden crop
3.	Open forest	Evergreen broad leafed forest,
4.	Close forest	deciduous forest, dries deciduous forest
5.	Scrub grass	Abandoned field covered by shrub

3.4.2 Unsupervised Classification

Unsupervised classification was done by algorithm ISODATA to cluster pixels in a data set based on statistics only, without any training area. This classification produced 40 classes through the satellite data and then reclassified it to five classes according to Table 3.2. Even classified data are regrouping; it still could not distinguish between scrub land and agriculture land. Finally, we conducted ground truth verification by field data.

3.4.3 Ground Truth Collection

Ground truth data collection was performed one time field trip from 25th Jan to 4th Feb, 2013. Survey was start from Aungban to Pindaya, Kalaw and Heho Township. GPS coordinates and pictures were taken along the way. The survey was conducted mostly along the Main Road of Aungban-Pindaya and Heho due to unfavorable road condition in many area and limitation of time.

Ground truth represents true land cover. Ground truth can be used as training data for supervised classification and validation data for the validation of the classified result. This ground truth collection was done to obtain accurate location point data for each land use and land cover class included in the classification scheme according to old land use 2000 map (Table 3.2) as well as for the creation of training sites and for generation of signature. Asking some informal questionnaires was also performed to confirm the previous land use during the field trip. Some part of Kalaw Chaung Sub-watershed could not go because of difficulties in transportation. Half of ground truth was used as training data to classify the images and the rest of half of ground truth was used as validation data to calculate the accuracy of classification.

3.4.4 Selection of Region of Interest (ROI)

Both the field experience and visual interpretation were applied to select the region of interest for different classes. Relatively larger number of pixels was included in each ROI in order to get a better statistical interpretation of each class.

Before setting the region of interest, five classes: water body, agriculture land, open forest, close forest, scrub grass land, are defined according to the existing land use map of 2000. The ROI were established for each class to get the classified images using half of ground truth data. Several points for each class were selected as ROI because reflectance value was changed according to different patterns in each class. NDVI images were derived from Landsat TM and Landsat ETM images. Old land use map and the wet season image were also used as reference images together with NDVI images in most heterogeneous area when setting ROI.

3.4.5 Supervised Classification

Supervise Classification procedures are the essential tools used for the extraction of quantitative information from remotely sensed image data. Maximum Likelihood classifier is one of the most popular methods of classification in remote sensing. The maximum likelihood classifier quantitatively evaluates both the variance and covariance of the category spectral response patterns when classifying an unknown pixel. To do this, an assumption is made the distribution of the cloud of points forming the category training data is normally distributed. This assumption of normality is generally reasonable for common spectral response distributions. Under this assumption, the distribution of a category response pattern can be completely described by the mean vector and the covariance matrix. (Lillesand and Kiefer, 2000)

Supervise classification was performed using ROI explain above. After supervise classification, the majority analysis is used to change spurious pixels within a large single class to a given class.

3.4.6 Accuracy Assessment

Accuracy is determined empirically, by selecting a sample of pixels from the thematic map and checking their labels against classes determined from reference data (ground truth). Most common and typical method to assess classification accuracy is an error matrix (a confusion matrix or contingency table). An error matrix is a square assortment of numbers defined in rows and columns that represent the number of sample units (i.e., pixels, clusters of pixels, or polygons) assigned to a particular category relative to the actual category as confirmed on the ground. The rows in the matrix represent the remote sensing derived land use map (i.e., Landsat data), while the columns represent the reference data (Jensen, 1986). These tables produce many statistical measures of thematic accuracy including overall classification accuracy (the sum of the diagonal elements divided by the total number in the sample), percentage of omission and commission error by category and the KHAT coefficient (an estimate of the Kappa coefficient, an index that relays the classification accuracy after adjustment for chance agreement) (Cohen, 1960; Congalton et.al., 1988). Half of the ground control points which were collected during the field trip used as validation data to verification of accuracy.

3.5 Preparation of Land Use Map

There was confusion in some classes after classification. The main source of confusion in the map is the agriculture class because it is diverse and includes a variety of different agriculture types. Most of the harvested paddy fields are homogenous with scrub land and some scrub land area during defining ROI. Deciduous forests are also confused with the scrub grass land because of falling leaves at that time. Some part of rivers and streams are also discontinuous because of influencing the reflectance of the surrounding area. Misclassification occurs between those classes. All classes of classified images were segmented to separate layers and exported as a polygon-vector format then converted into shape files in ArcGIS software for additional GIS analysis. Overlaying with dry and wet season images, checking the reflectance value of each band and NDVI values of both images and digitization also made to correct them is classification. Each polygon maintained the pre-assigned land use code corresponding to each land category. Simplification is also need to smooth the lines on the map to eliminate unnecessary detail. Aggregation is the combination of same type of nearest polygons which are combining into one. So simplification and aggregation were carried out to get the suitable land use map.

4. Result and discussion

4.1 Land Use and Land Cover Classification

The land use and land cover classification of the study area was analyzed by using Landsat TM data in 1990, Landsat ETM data in 2000, and Landsat ETM data in 2010. There was some confusion in satellite images during setting region of interest (ROI). The deciduous forest and paddy fields have changed according to season so they are indistinguishable on single date image.

The wet season image and NDVI images of each year also was used as reference images during the classification step because deciduous forest, harvested paddy field, scrub grass land were confused with the other classes or each other. It was impossible to separate, some part of scrub grass land area and harvested paddy field.

The overall accuracy of classified image of Landsat TM 1990 was 81.6%, Landsat ETM 2000 was 85% and Landsat ETM 2010 was 88.6%. These classified images' accuracies were more than an acceptable accuracy of 80%.

Segmenting the images into separate layers of each class and converting into vector format was generated in ArcGIS. Manual digitizing and map generalization such as simplification and aggregation were also done as described in previous section in order to get the accurate land use map. The results of land use land cover map of 1990, 2000 and 2010 are shown in Figure 4.1, 4.2 and 4.3.

The statistic data of each land use class for each year were calculated using query language in ArcGIS 9.3. Open forest cover was 66 % in 1990, 28 % in 2000 and 10 % in 2010. Agriculture land was 2 % in 1990, 15 % in 2000 and 56 % in 2010. Detail information based on land use types for years 1990, 2000 and 2010 are shown in Table 4.2 and 4.3.

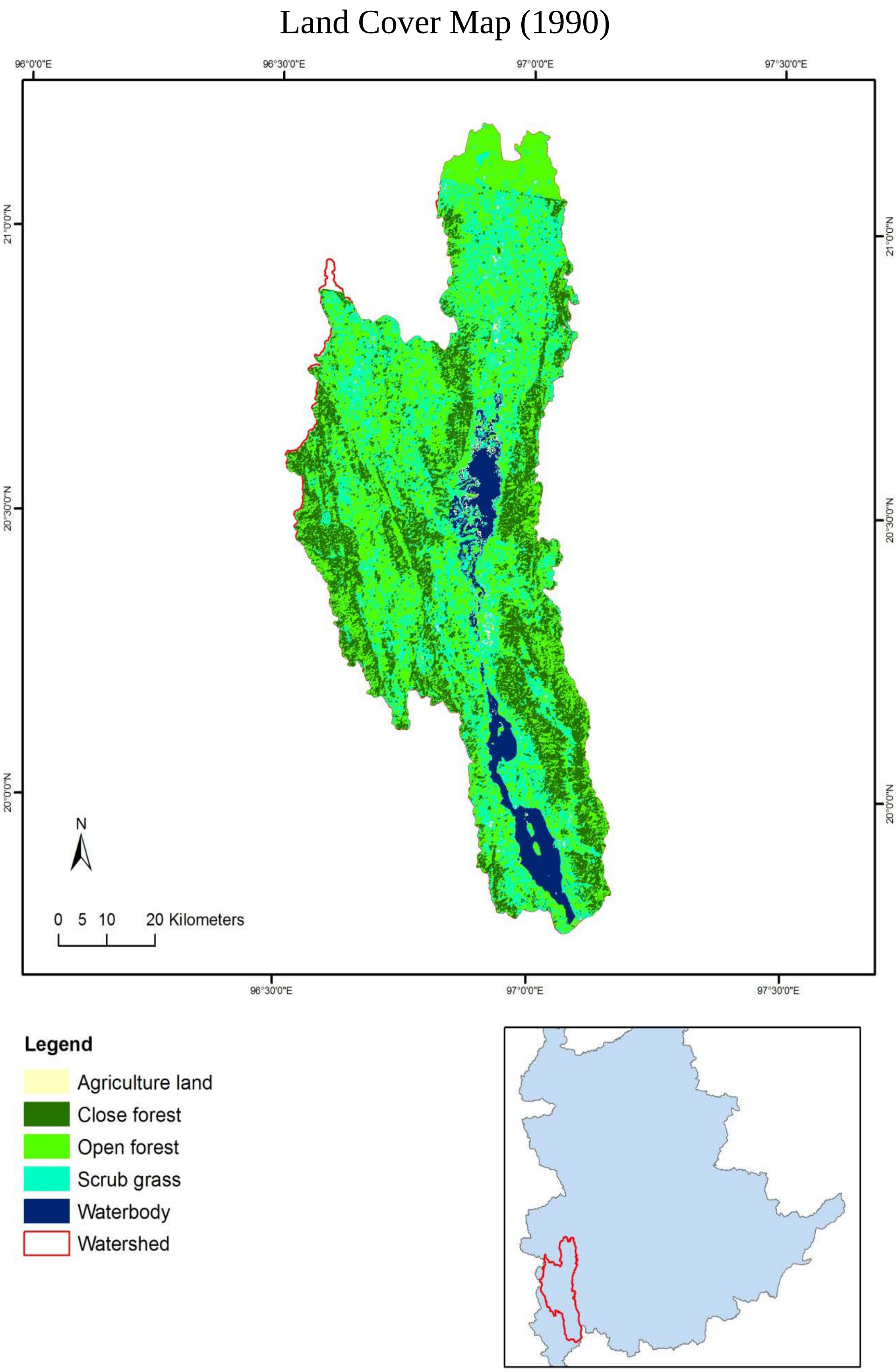


Figure 4.1 Land Use and Land Cover Map of the study area (1990)

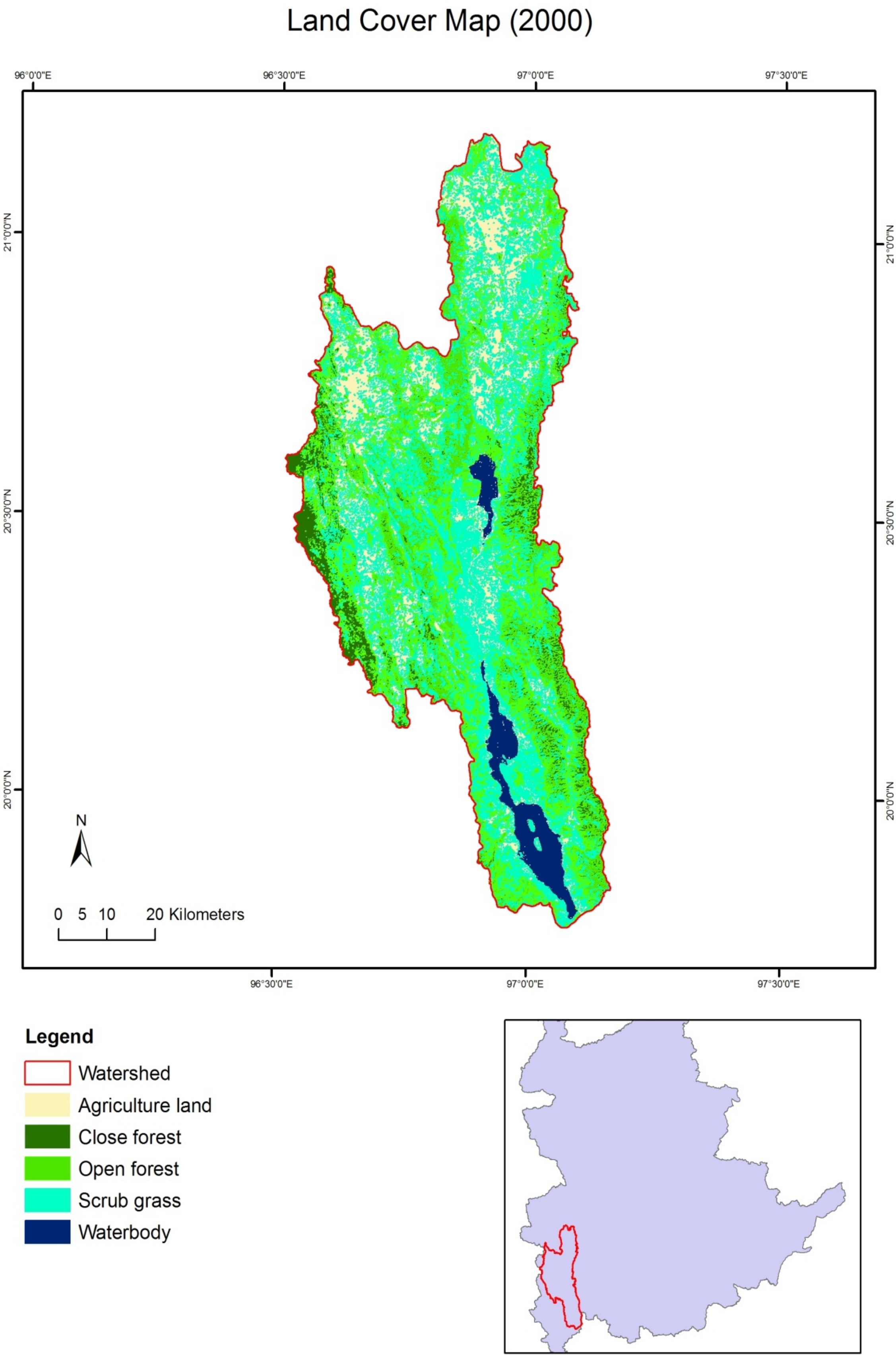


Figure 4.2 Land Use and Land Cover Map of the study area (2000)

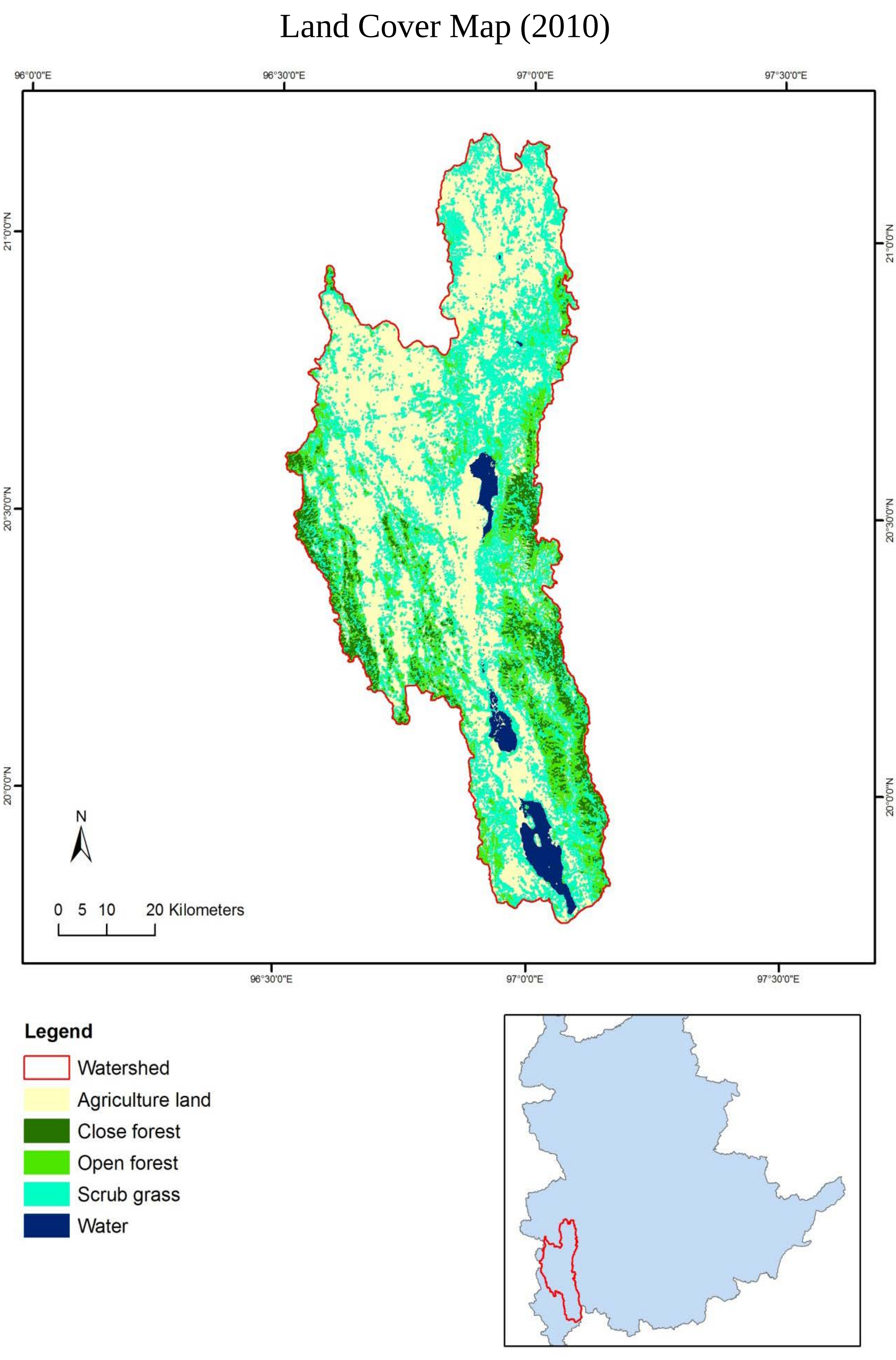


Figure 4.3 Land Use and Land Cover Map of the study area (2010)

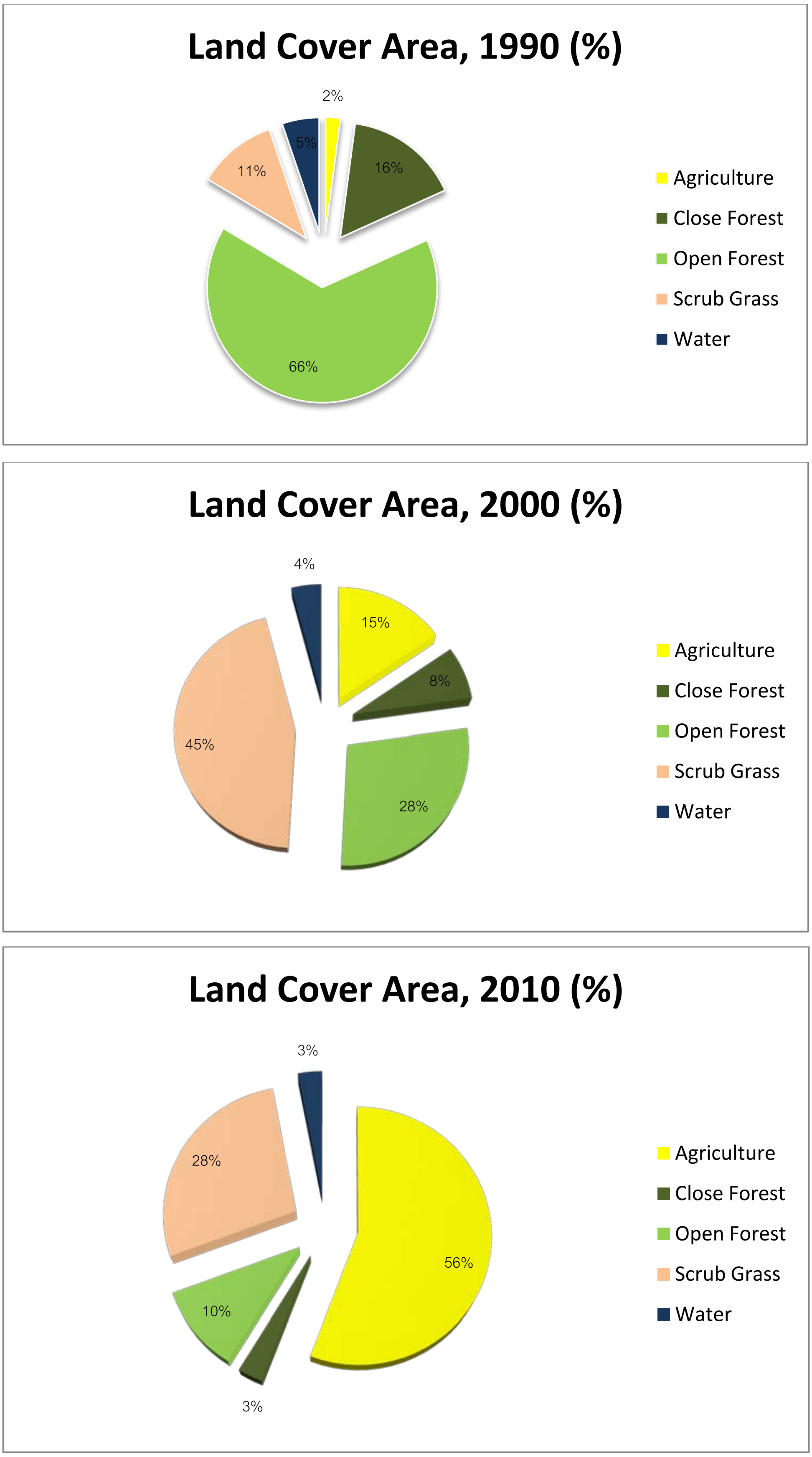
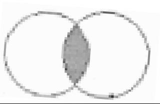
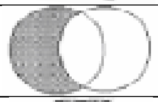
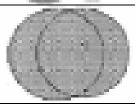
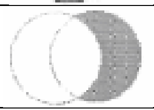


Figure 4.4 Land use and Land cover percentages of the study area (1990, 2000 and 2010)

4.2 Detection of Land use / Land cover changes

Geo-processing tool and logical function was applied to detect and quantify the land use change. The basic tools used in land use/ land cover change are shown in following Table 4.1.

Table 4.1 GIS functions in land use/ land cover analysis

Geo-processing	GIS function	Result in land use/ land cover Change
	Intersection	Unchanged area between Date 1 and Date 2
	Intersection and Erase	Area lost between Date 1 and Date 2
	Union	Not immediate interest
	Union, Intersection and Erase	Area gained at Date 2

4.3 Quantitative Change Detection and Discussion

The result indicates that land use land cover changes between year 1990, 2000 and 2010 in Inle Watershed, Myanmar. The analysis method was detected based on geo-processing (union, intersection and erase). Result of intersection between two maps gave unchanged area and result of intersection using together with erase and union predicted changed area (lost area and gain area) within 20 years. The statistical data of change detection is shown in Table 4.2 & 4.3.

In Table 4. 3, there were major changes in open forest agriculture land and scrub grass land. Open forest had been reduced up to 39.63% between year 1990 and 2000 and scrub grass land had been increased up to 35.80 %. Between 2000 and 2010, agriculture area was highly in increased up to 50.44 and open forest was decreased up to 21.51 % at the same period. According to the change detection of land use/ land cover between 1990 and 2010, open forest had been reduced up to 38.87 % and agriculture land was increased up to 38.33 %.

The most change occurred in open forest because of the demand on expand the land for agriculture was increased due to shifting cultivation and the pressure of population. Other additional changes of land use/ land cover are shown in Table 4.2 & 4.3.

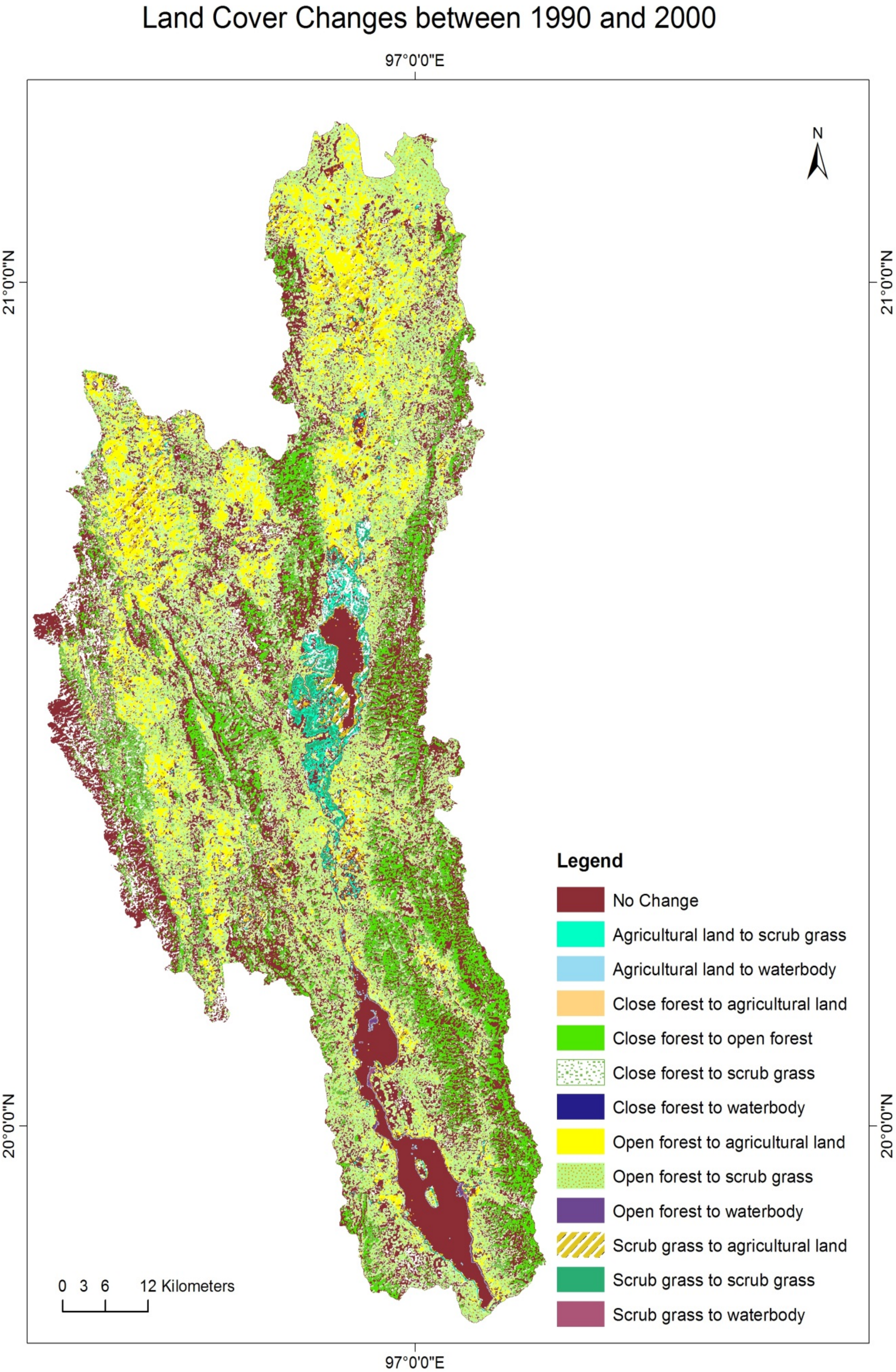


Figure 4.5 Land use/ Land cove changes between 1990 and 2000

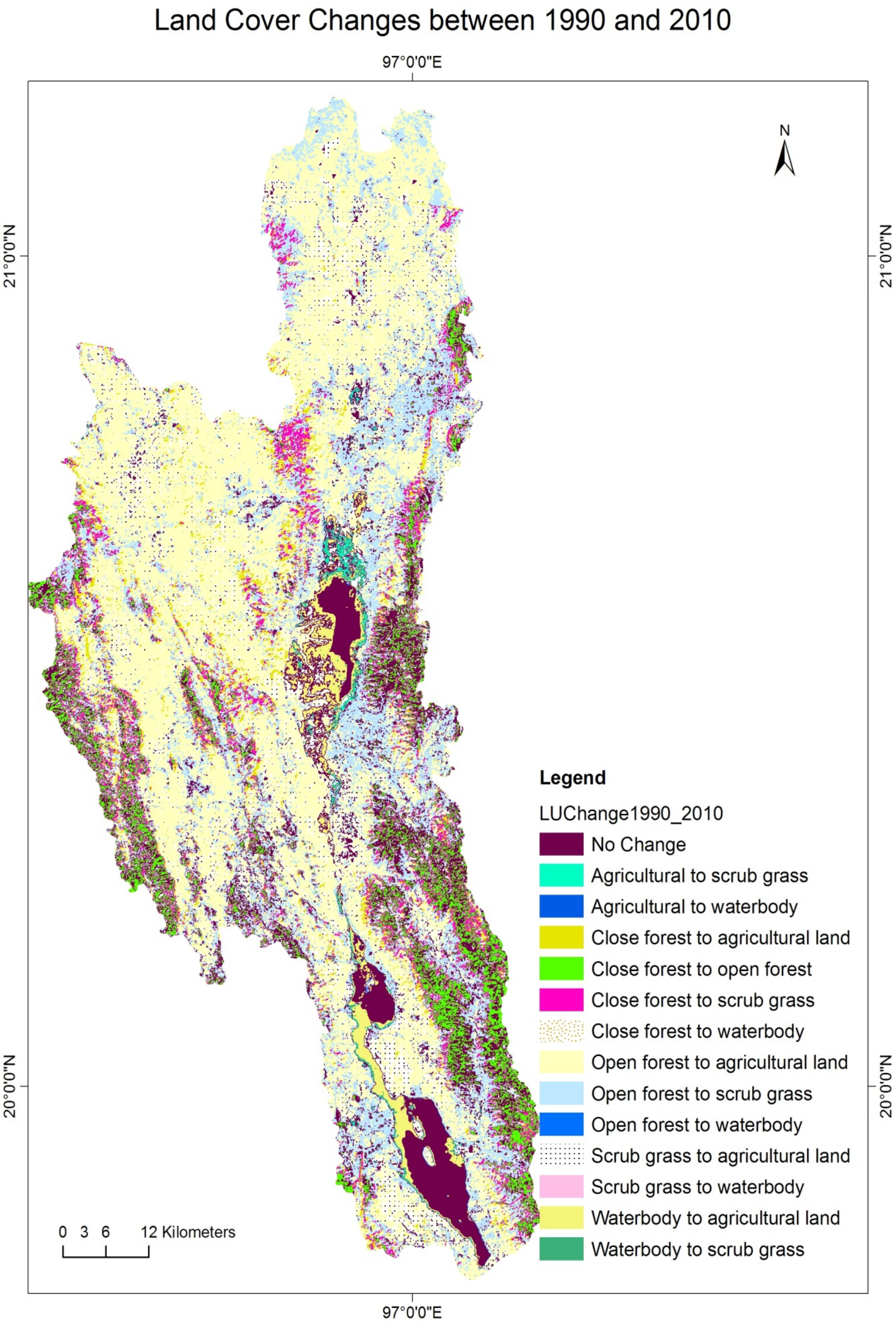


Figure 4.5 Land use/ Land cove changes between 1990 and 2010

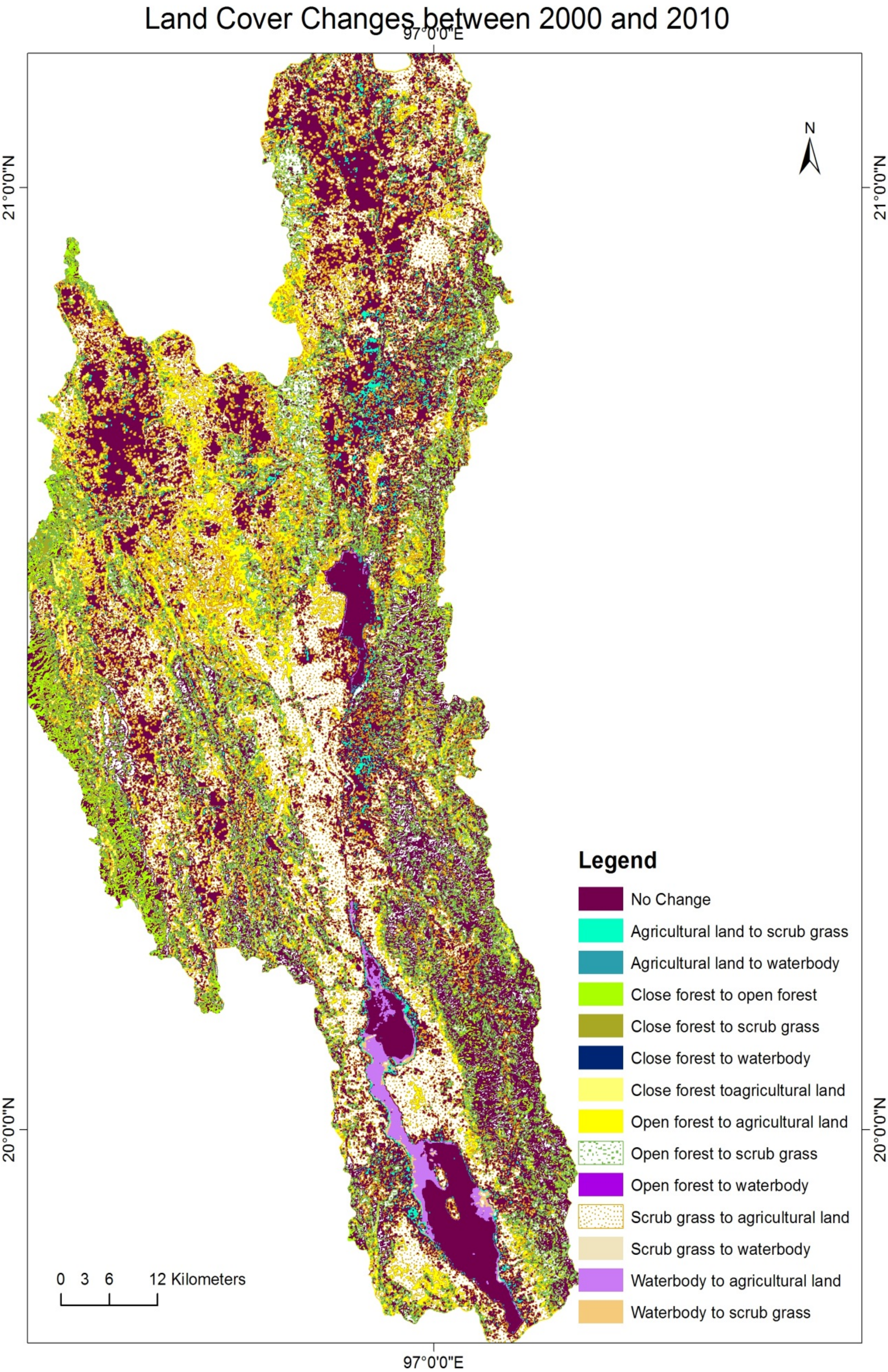


Figure 4.6 Land use/ Land cove changes between 2000 and 2010

Table 4.2 Changes of Land use/ Land cover of the study area among year of 1990, 2000 and 2010

No	Change Class	Land use/ land cover changes between 1990 and 2000		Land use/ land cover changes between 1990 and 2010		Land use/ land cover changes between 2000 and 2010	
		Area (ha)	Area (%)	Area (ha)	Area (%)	Are a(ha)	Area (%)
1	Agricultural land to scrub grass	6214.05	1.20	2422.89	0.45	10574.46	1.95
2	Agriculture land to close forest	-	-	-	-	1.08	0.00
3	Agriculture land to open forest	-	-	-	-	199.62	0.04
4	Agricultural land to water body	908.55	0.18	310.14	0.06	501.93	0.09
5	Close forest to agricultural land	986.22	0.19	16318.80	3.02	4453.92	0.82
6	Close forest to open forest	49206.87	9.53	30228.12	5.60	15611.13	2.87
7	Close forest to scrub grass	13391.46	2.6	28905.84	5.36	10444.14	1.92
8	Close forest to water body	1.62	0.00	53.64	0.01	3.06	0.00
9	No Change	175657.77	34.03	74426.31	13.79	201439.53	37.06
10	Open forest to agricultural land	61098.39	11.84	220953.69	40.94	52859.16	9.73
11	Open forest to close forest	-	-	-	-	5649.57	1.04
12	Open forest to scrub grass	184702.95	35.78	105691.23	19.58	59695.65	10.98
13	Open forest to water body	523.71	0.10	48.87	0.01	17.91	0.00
14	Scrub grass to agricultural land	18425.07	3.57	47856.24	8.87	168709.68	31.04
15	Scrub grass to close forest	-	-	-	-	381.06	0.07
16	Scrub grass to open forest	-		-	-	6479.55	1.19
17	Scrub grass to scrub grass	4433.13	0.86	-	-	-	-
18	Scrub grass to water body	638.73	0.12	145.26	0.03	66.24	0.01
19	Water body to agricultural land	-	-	10776.69	2.00	5468.85	1.01
20	Water body to scrub grass	-	-	1520.73	0.28	928.53	0.17
	TOTAL	516188.52	100.00	539658.45	100.00	543485.07	100.00

Table 4.3 Statistical Data of Land cover changes between 1990, 2000 and 2010

Statistical Data of Land Cover Change between 1990 and 2000

No	Class Name	Area (ha)	Area (%)
1	Agriculture	72,148.14	14.05
2	Close Forest	-47,957.85	-9.34
3	Open Forest	-203,519.88	-39.63
4	Scrub Grass	183,842.73	35.80
5	Water	-6,112.26	-1.19
	Total Change Area	513,580.86	100.00

Statistical Data of Land Cover Change between 2000 and 2010

No	Class Name	Area (ha)	Area (%)
1	Agriculture	221,873.67	50.44
2	Close Forest	-24,306.30	-5.53
3	Open Forest	-94,609.89	-21.51
4	Scrub Grass	-93,184.56	-21.19
5	Water	-5,877.81	-1.34
	Total Change Area	439,852.23	100.00

Statistical Data of Land Cover Change between 1900 and 2010

No	Class Name	Area (ha)	Area (%)
1	Agriculture	294,021.81	38.33
2	Close forest	-72,264.15	-9.42
3	Open forest	-298,129.77	-38.87
4	Scrub Grass	90,658.17	11.82
5	Water	-11,990.07	-1.56
	Total Change Area	767,063.97	100.00

5. Conclusion

In this study, three Landsat images acquired in 1990, 2000 and 2010 were used for land use and land cover change detection of the Kalaw Chaung Sub-watershed of Inle Lake in Myanmar. Land use/ land cover mapping and change detection has progressively more been recognized as one of the most effective tools for management of environmental resources.

Different types of Land use/ Land cover mapping and their change detection were carried out using digital image processing techniques cooperating with remote sensing and geographic information system.

The satellite remote sensing was useful tool for monitoring and management of land use and land cover change. The hybrid classification technique using the Maximum Likelihood approach has proven to be better and more accurate than the Minimum Distance method.

The major change of land use and land cover was occurred in agricultural land and close forest in 1990, 2000 and 2011.

Spatial modeling of land use and land cover change with the application of Remote Sensing (RS) and Geographic Information System (GIS) proved cost effective environmental monitoring and evaluation.

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