SUSTAINABLE DEVELOPMENT CONFERENCE

7-9 JULY 2016

KUCHING

MALAYSIA

CONFERENCE PROCEEDINGS

Tomorrow People Organization

Dušana Vukasovića 73, Belgrade, Serbia

www.tomorrowpeople.org

Proceedings of international conference:

" SUSTAINABLE DEVELOPMENT CONFERENCE 2016"

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Producer: Tomorrow People Organization

Publisher: Tomorrow People Organization

Quantity: 200 copies

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Agricultural Extension Access in Model Villages: Evidence from Rural Northwest Nigeria

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ABSTRACT

The smallholder farmers who are mainly peasants constitute majority of the agricultural workforce in rural Nigeria with weak to very weak agricultural extension access. The paper explores the historical antecedent of the near-comatose public extension services.

The scenarios had created a serious gap in the agricultural knowledge dissemination and information sharing between actors and have not foster opportunities for collaboration and partnership. Bearing in mind that agricultural extension is institutionally weaker in the farmer-extension-farmer continuum; the University Outreach Extension strategy appears to be a panacea in creating an extensive bottom-up engagement in farming issues, agro-technology generation and transfer in the farming system and respond to the agricultural extension and rural development needs of farmers have been established in model villages in rural Northwest Nigeria.

Introduction

In rural Nigeria, the pervasive poverty is often blamed on lack of capacity building of farmers as a result of numerous ineffective strategies employed in handling it. If poverty is to be reduced, productivity of the agricultural sector must be enhanced. However, agricultural productivity will not increase if the capacity of farmers and other actors in the agricultural value chain remains low, preventing them from innovating. Innovations could include new agricultural knowledge or technologies related to primary production, processing and commercialisation-all of which could positively affect productivity, competitiveness and livelihoods of rural folks. Farmers represent the majority of people living and earning their living in rural areas.

Agricultural extension has been recognised as an indispensable factor in the practice of farming and it is the basis of extension service delivery. Farmers require a diverse range of agricultural information to support their farm enterprises. Davis (2009) reported that agricultural extension, or agricultural advisory services, comprises the entire set of organisations that support people engaged in agricultural production and facilitate their efforts to solve problems; link to markets and other players in the agricultural value chain; and obtain information, skills, and technologies to improve their livelihoods. Swanson (2008) also reported that transfer of technology still has relevance since agricultural extension is now seen as playing a wider role by developing human and social capital, enhancing skills and knowledge for production and processing, facilitating access to markets and trade, organising farmers and producer groups, and working with farmers toward sustainable natural resource management practices. Within this expanded role, the breadth of information that agricultural extension can support through provision and facilitating access and sharing is much larger. In addition, as the agricultural sector has become more complex, farmers' access to sources of reliable and relevant information has become increasingly important. Apantaku, Oloruntoba and Fakoya (2003) examined smallholder farmers' involvement in agricultural technology generation and utilisation. Found that the level of farmer's involvement in the agricultural problem identification and prioritisation was low because majority of the technologies were not based on farmers identified problems and felt-needs.

Problem Statement

Most farmers in rural Northwest Nigeria appeared to have low or little access to agricultural extension as a source on modern agro-technologies despite the presence of the State-wide Agricultural Development Programme whose primary responsibility was to disseminate improved innovation to farmers. The paucity of funds, inadequacy of extension agents require to make contacts with farmers which need to reach a large and complex farming community, inappropriate and poor quality information sharing among farmers are some of the reasons for non-performance. In other words, the content of the information provided by agricultural extension and the information farmers actually need appeared not to be aligned. Cursory observation revealed that farmers in the Federal University Dutse Agricultural Extension Outreach Centre model villages in particular have no access to scientific and technological information that could help improve their capacity and ultimately agricultural productivity as reflected on the continuous reduction in agricultural production in the area. The paper examines the agricultural extension access of farmers and attempt to find answers to the following research questions:

- Do smallholder farmers have access to agricultural extension as and when required?
- What strategy has emerged to counter the emerging challenges/constraints militating against smallholder's farmers' access to agricultural extension?

Literature Review

Farmers require a diverse range of agricultural information to support their farm enterprises. Agricultural information is knowledge that farmers seek from extension services, fellow farmers, family and relatives and from media. van den Ban (1998) posited that farmers require information related to most appropriate technological options and management of technologies. Dulle (2000) reported that agricultural research results constitute an important knowledge base that should be made available to farmers for increased food production. Vuuren (2007) found that much of the knowledge generated by scientific research ended up on shelves and it is inaccessible to the farmers. Swanson (2008) noted that transfer of technology still has relevance since agric extension is now seen as playing a wider role by developing human and social capital, enhancing skills and knowledge for production and processing, facilitating access to markets and trade, organising farmers and producer groups, and working with farmers toward sustainability

Olowu and Oyedokun (2000) reported that several channels such as extension agents, individuals, farmer-to-farmer contact, print media (newspapers, magazines, newsletters, leaflets, pamphlets, and posters) and electronic media (radio, television, film, slides and film strips) have been widely used to disseminate information to farmers. Agricultural extension agents provided HIV/AIDS information for only 37.9% of the farmers. This is low in view of the redefined role of extension agents. In addition to the dissemination of proven farm technologies, extension agents are expected to disseminate HIV/AIDS awareness information to farmers (Egbule and Njoku, 2001).

According to Anyanwu *et al.* (2002) educational attainment predisposes one to using different sources of information, emphasis being more on professional rather than inter personal sources of information. In other words, the more educated an individual, the more exposed the person becomes to sources of information. Rees *et al.* (2000) reported that most Kenyan farmers considered their most pressing information requirement which was not being adequately addressed as technical details of farming from the agricultural extension. Farmers need to be informed and educated about improved agricultural practices to enable them increase their productivity and income.

Kuponiyi (2000) opined that radio and television are important sources of agricultural information in Nigeria. Girard (2001) observes that radio undoubtedly remains the most important medium in Africa since low levels of literacy, distribution problems of newspapers and the cost of television leaves it the most accessible medium.

Ajayi (2003) reported that radio was the most popular among farmers in Southwest Nigeria. The popular use of radio by farmers is probably due to the fact that many farmers can afford to purchase a transistor radio as it is cheap, more accessible and easy to maintain than other mass media. Radio has a high capacity of creating

awareness for new technologies and stimulating people to get involved. In India, it has been documented that radio and television accounted for 13 percent and 9.3 percent sources of information accessed by farmers respectively (NSSO, 2005).

In Fiji, radio and television accounted for more than 80 percent coverage of agricultural information and could be used to broadcast quality programmes to impact agricultural populace. Again, in central Punjab, India more than 56 percent farmers listened to radio and watched agricultural programme on television (Abbas *et al.*, 2003). According to Onemolease (2002), sources of agricultural information through friends and relatives have profound effect on level of access to information needs by farmers. However, the relatively low patronage of media channels may be attributed to poor coverage, poor reading habits and weak purchasing power of farmers (Ayankogbe *et al.*, 2003).

According to FAO (2002), rural women and girls usually have less access than men to information and new technologies. Without equal access to agricultural information, they are at a disadvantage in making informed choices about what to produce and when to sell their product. However, in spite of research and extension services efforts, Adereti *et al.*, (2006) stated that there are improved packages on agricultural production that are not being adequately used by farmers.

Agricultural Extension Access Transformation Path

Agricultural extension access refers to quality, quantity and timely agricultural information available to farmers through agricultural extension. Access to adequate agricultural extension services is very essential to increased agricultural productivity of farmers. Deribe (2007) and Ebrahim (2006) indicated that access to extension services has significant influence on adoption of agricultural technologies. Therefore, the frequency of extension contact has important role in the access to and utilisation of agricultural technologies. Samuel (2001) posited that agricultural information for decision-making must be acquired and used in order to make an informed decision. Agricultural extension is simply information communication in agriculture. Farmers have different information needs during each stage of agricultural production process ranging from weather forecasts, pest and diseases attacks, inputs (seeds and fertilizers), improved cultivation practices and prices. Broadly speaking, agricultural extension is the delivery of information inputs to farmers (Anderson and Feder, 2007).

Fig 1 presents an agricultural extension access transformation path. It illustrates the direction of the strengthening of agricultural extension access by smallholder farmers. Accessibility connotes the ability of farmer or group of farmers to obtain agricultural information needed for agricultural production in a relevant and timely manner. If farmers received appropriate agricultural extension services, this could lead to improved agricultural information and accessibility, farmers could then transformed as follows:

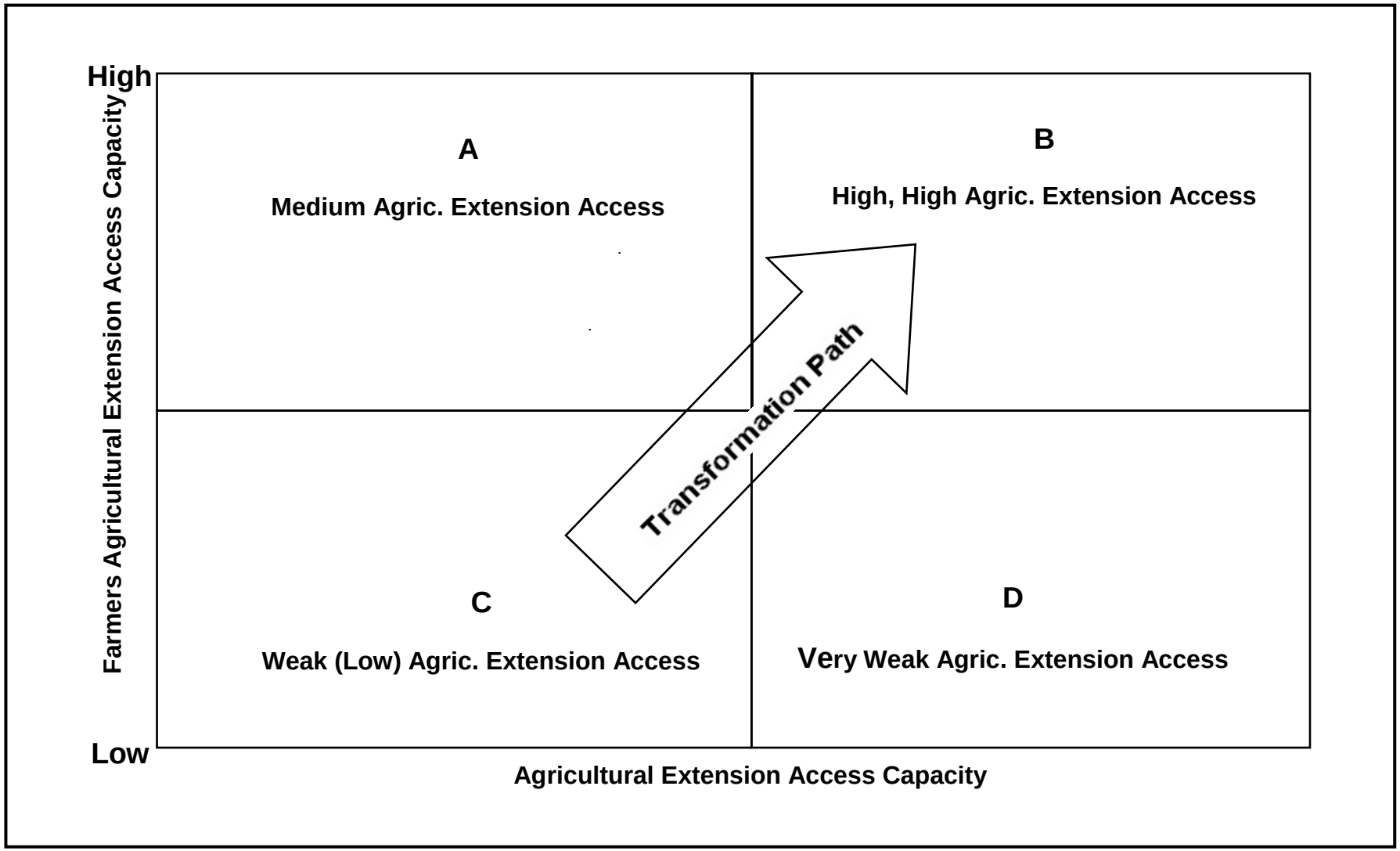

Fig.1: A typology of Agricultural Extension Access Transformation Path

Source: Authors (2016)

Box D = VWA; Box C = WA; Box B = MA; and Box A = HHA

If a farmer remains with Very Weak Agricultural Extension Access (Box D), meaning the lack of improved agricultural technology / accessibility. If a farmer is found at Medium Agricultural Extension Access Capacity (Box B), it will follow the strategy of enhancing the use of improved agricultural technology/accessibility to transform to High, High Agricultural Extension Capacity (Box A). The current status of the farmers in University Model villages reflects a Very Weak Agric Extension requiring the intervention of the University Outreach Centre to transform it to Medium or High Agric Extension Access Capacity. Rola *et al.*, (2001) reported that a critical challenge for extension lies with conveying the major advances in agricultural technologies and markets to farmers efficiently, in timely manner that ensures proper utilisation by the farmers

According to Berhanu *et al.,* (2006), extension is a service of information, knowledge and skill development to enhance adoption of improved agricultural technologies and facilitation of linkages with other institutional support services (input supply, output marketing and credit). Birner *et al.,* (2006) reported that agricultural advisory services in developing countries today have assumed a much more holistic and facilitator's role, and the field staff of an agricultural advisory service is not just a conduit of information, but an advisor, facilitator, and knowledge broker. The characteristics of a good information source are relevance, timeliness, accuracy, cost effectiveness, reliability, exhaustiveness and aggregation level (Statrasts, 2004).

Public Extension System in Nigeria

The Nigerian Government has been adopted and implemented different types of extension approaches to boost agricultural production across the country. As the historical account of the country's agricultural extension approach portray, it has evolved over the years and was initiated in the nineteenth century by the early missionaries which focussed on the production of export crops. The method was known as the **Commodity Extension Approach**.

Various approaches have evolved since the independence in 1960. These include extension under the **Ministry of Agriculture Approach** which was tied to bureaucratic principles of the government ministry. The **Farm Settlement/Farm Institute Leavers' Extension** of 1959 to 1965 designed to reduce rural-urban drift but was purely top-down strategy. In 1972, the **National Accelerated Food Production Programme** was launched which employed participatory technology development but with minimal involvement of farmers in farm trials known as 'mini-kits'. In 1976, the **Operation Feed the Nation** was introduced as a strategy to mobilise the general public to participate in food production through supply of input without articulated extension system. The River Basin Development Authority was established in 1977. Then the Green Revolution in 1979 premised on the Green Revolution success story in Asia but the approach did not have a focussed and was unsustainable.

The **Pilot (Enclave) Agricultural Development Projects** started in 1975 and later metamorphosised to the State-wide Agricultural Development Programme in 1989 which basically emphasised the Training and Visit (T&V) approach propounded by Benor and Baxter (as cited by Omotayo *et al*. 2001) and promoted in Nigeria and other countries by the World Bank. This approach operated a separate organisational structure with tripartite funding from the Federal Government, State Governments and the World Bank. There were many criticisms levied against this strategy (Ogunfiditimi and Ewuola, 1995).

The **Unified Agricultural Extension System** was introduced as an amendment of the ADP model. In this arrangement, one Village Extension Agent (VEA) is expected to teach farmers improved farm practices in all areas including crops, agro-forestry, animal production, fisheries and processing using the T & V system. However, the approach has been variously criticised due partly to its non-sustainable nature. This government-funded extension programmes have been found not to be participatory, but top-down as farmers had no room to participate in extension policy. Information flow has been largely top-down to the end users. Hence, the link between extension and research putting farmer at the centre of technology generation has been overlooked. This was partly due to the dearth of agricultural extension workers responsible for dissemination of agricultural information to farmers and probably because information was not well aligned to sustainable farming practices.

University Agricultural Extension in Nigeria

The Universities have come to the rescue because Agricultural extension in the country has been and still remains largely public sector-driven. Recently, universities have embarked on extending access to agricultural information to communities through Extension Outreach strategy. Basically Universities were established to provide leadership, advance learning through teaching and research. Serve as beacon to the society in terms of outreach. For instance, Some attempts have been made with success with the Isoya Rural Development Project of the Obafemi Awolowo University Ile-Ife, Badeku Project by the University of Ibadan, Extension Village Model at the Federal University of Agriculture, Abeokuta, Maigari Project of the Ahmadu Bello University Zaria and lately in the last quarter of 2014, Federal University Dutse established the Agricultural Extension Outreach Centre.

The outreach by definition is any programme of activities initiated and designed to meet the information needs of an un-served or inadequately served target group (Young, 1983). Oloruntoba and Adegbite (2006) posited that, university outreach is an educational and an action-research-based information source enabling farmer to make decisions that improves quality of lives. It is therefore the art and science of understanding and responding to the needs and wants of groups of people.It is often built around a commitment to information flow across segments or niches.

The establishment of the Outreach Centre at the Federal University Dutse was consequent upon the need to extend practical knowledge acquired from research to the host communities. This would promote partnership and development by bringing the *'town and gown'* together through action-research and extension outreach. The benefit of transferring and disseminating improved technologies to the communities is expected to empower them to take control of their own affairs, foster inclusiveness, build capacity and increase the efficiency with which resources are used for the benefit of the target communities. It would also create a congenial atmosphere between the university and the host communities through various intervention projects to be embarked upon in due course. From the out-set, the Centre was designed as an innovative and emerging institution to cater for the extension information needs and wants of farmers, farmers' groups and communities around the University in Dutse. The outreach is an effort by the Centre to connect its ideas or practices to the efforts of other organisations, group or specific audiences. The outreach was built around a commitment to information flow across diverse target beneficiaries from those engaged in farming, to those displaced from their farmland, and would inform the type of extension information needs and advice to be given. In the context of the Extension Outreach, focus would be on the extension information needs of the underserved or inadequately served target communities around the university.

Mission Statement
To create an enabling environment that would strengthen the structural base of local communities through action-research, extension, capacity building, quality learning and adoption of proven technologies.

Overall objective
To ensure that communities in 'model villages' are linked with potential partners to access agricultural extension information and skills for the improvement of their farms and homes.

The specific objectives are to:

- build capacity and ensure technology transfer to farmers, local communities, change agents and students;
- link communities with potential partners and development agencies to become efficient and effective in availing themselves of their services;
- mobilise and develop communities toward self-reliance;
- make the university responsive to the needs and aspirations of the host communities.

The acquisition of large expanse of land for infrastructural development in educationally-disadvantaged agrarian communities was laudable and hoped to confer enormous benefits to the catchment areas. The negative consequence however was the displacement of the original owners of the land which was not only immediately disruptive but could be fraught with heavy long-term risks. Cultural heritages and important landmarks have disappeared, sensitive habitats destroyed and rare biological resources irretrievably lost as a result of implementation of the projects considered to be highly beneficial to mankind. With respect to negative social impacts of such projects; there are instances where displaced people have been reported to become more impoverished in their new settlements than they were before displacement. Cases also abound where people become more economically vulnerable and socially disintegrated. Although, the displaced communities appears to have settled down since 2012, their loss of farmland, water points, schools and clinic tend to increase the level of poverty of the affected persons; especially women and children folk. To the rescue, the land owners were adequately compensated and resettled as model villages around the University campus.

Situation Analysis
There is little available information and data about the socio-economic and demographic imperatives of households in the model villages. But the baseline survey by Oloruntoba *et al*. (2015) revealed that the six model communities bordering the University are: Maja, Bulori, Gurungu, Hausawa, Kargo and Kawayi which were contiguous villages to each other and located on 2811 hectares of land (Fig. 2). Typically, a village is a common type of settlement which consists of many farmers' dwellings either with their farms or some distances away from the village. Hence, these rural village communities are made up mainly of nucleated with few dispersed settlement patterns, homesteads, barns, schools and mosques frequently visited by the inhabitants. Local mini-markets are usually found at the village square with main markets located in near-by major towns; the boundary of the community though might not be very distinct from another but has been spatially mapped. The inhabitants are mainly Hausas with few Fulanis and other ethno-linguistic groupings. The primary occupation is mainly subsistence farming with little or no access to agricultural extension. The predominant cropping system is intensive cultivation of rain-fed mixed cropping. Arable crops commonly

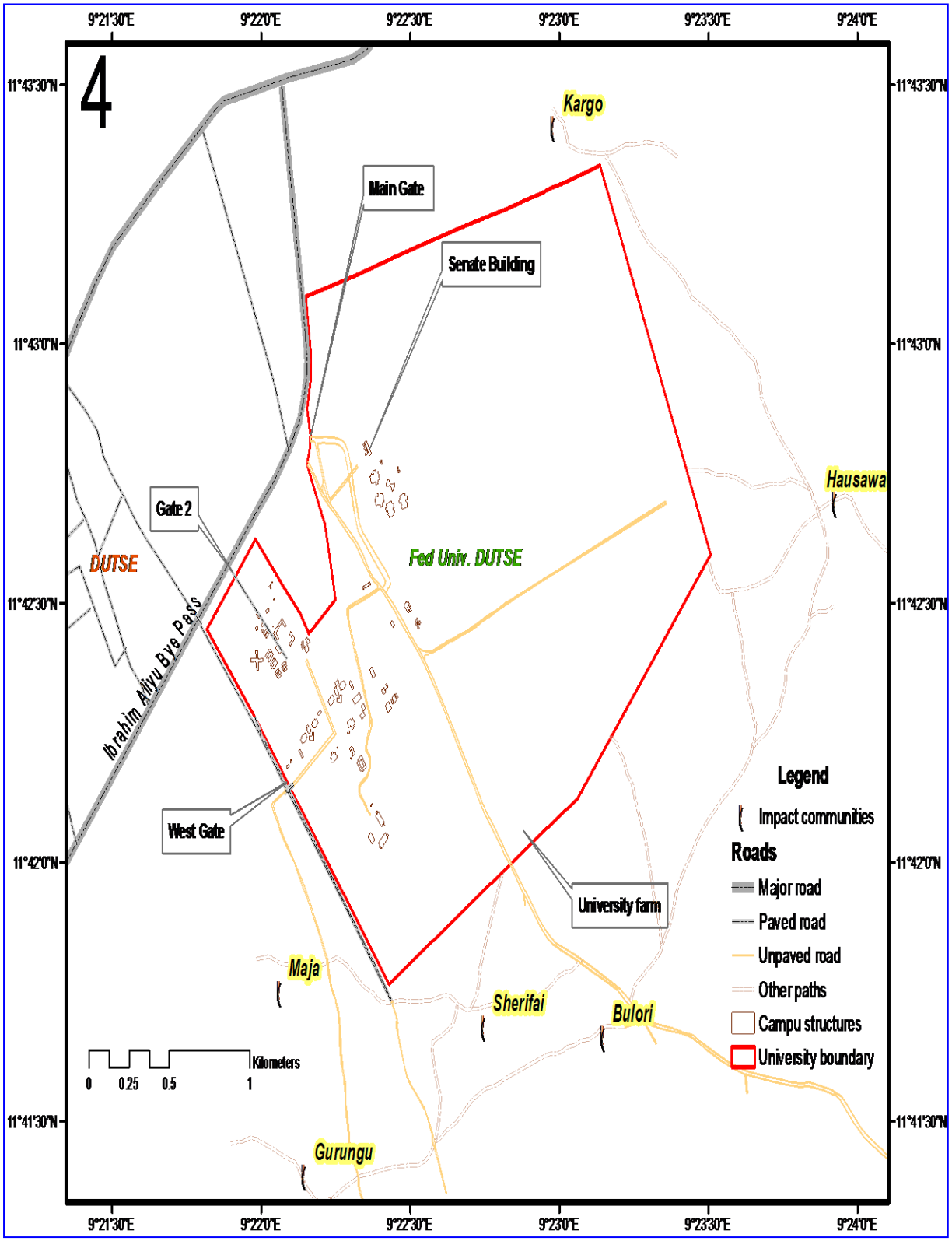

Fig. 2: Spatial Map of Outreach Communities at The Federal University Dutse Campus
(**Source:** Field Survey Oloruntoba *et al*., (2015)

cultivated include millet, maize, sorghum and beans. The soil types ranged from aeolian sandy soil to iron rich laterite.

Table 1 presents the estimated population, average household size in model villages. Estimates based on Oloruntoba *et al*., (2015) suggested that the communities have about 12,200 people with 1916 households as presented in the Table 1 and Fig. 2. Findings also show that the six communities are male-headed with overall mean household size of 8 persons. Kargo has andthe highest of 11 and Gurungu the lowest of 3 persons per household. The survey further revealed that the annual mean and median of household incomes in the communities were N185, 533.3 (US$942) and N134, 083.3 (US$681) respectively depicting poverty.

Table 1: Estimated Population and average Household size in Model Villages

Community	Estimated Population	Estimated HH	HH Sample size	Av. HH size	Overall HH Size
Bulori	2300	163	68	8.0	
Gurungu	1400	530	53	2.6	
Hausawa	3500	635	54	5.5	
Kargo	3500	317	120	11.0	**7.6**
Maja	1000	117	29	8.5	
Sharifai	1500	154	33	9.7	
Total	**12, 200**	**1,916**	**357**	-	

Source: Field Survey Oloruntoba *et al.* (2015)

The educational level was generally low with low school enrolment rate with only one primary school. Generally, smallholder' is characterised by highly fragmented small farm size and a weak link to extension system. Therefore, most smallholder farmers are usually affected by prices, subsidies and markets, but the input and output markets, which are not fully formed, remain localised to some extent. Smallholder farmers in the communities are highly vulnerable to inadequate agricultural extension access which is a major challenge to agricultural productivity. The term smallholder farmer is synonymous with small-scale farmers, resource-poor farmers, peasant farmers, food-deficit farmers, household food security farmers, land-reform beneficiaries and emerging farmers (Machethe *et al.*, 2004). The main criteria often used to classify farmers as smallholders by various analysts also include: land size, purpose of production (subsistence or commercial), and income level.

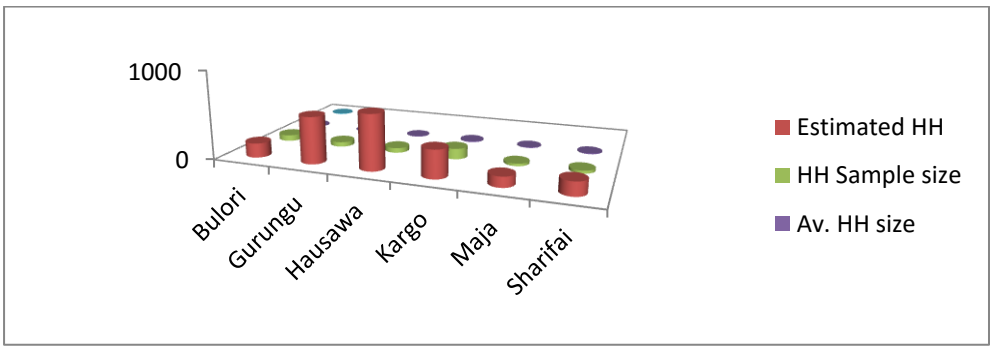

Fig 2: Average Household Size by Community
Source: Field Survey Oloruntoba *et al.* (2015)

Strategies for Agricultural Extension Access

The strategies for agricultural extension access in the communities are linked to the mission, objectives and activities. The realisation of any initiative is attributable to three complementary sets of factors including:

- A high concentration of talents and team building;
- Abundance of resources;
- Supportive regulatory framework.

The dynamic interaction among these three factors is the distinguishing characteristic of high ranking successful initiatives. Consequently, the Centre will avail itself with the pool of intellectuals available within and outside the University such as local and international NGOs to partner in making extension delivery accessible to the communities. To this end, the pre-intervention and implementation strategies are as follows:

Pre-Intervention Strategy

The understanding of the peculiar characteristics of the communities is an essential requirement in planning and implementing useful and sustainable socio-economic empowerment programmes for improving the livelihoods of the communities.. It should be noted that the degree of participation in any intervention generally depends on the needs, opportunities, level of motivation of both individual and community, which is an essential condition for making agriculture and rural development intervention sustainable, while the lack of their involvement may lead to apathy and generate dissidence, neglect and abandonment of intervention.

To this end, a baseline surveys that provided useful in-situ information on the socio-economic and demographic characteristics of the households was concluded in 2015 in the model villages using appropriate methodologies that will generate adequate information and stimulate households' participation in the planning process. The outcome from the survey would hopefully lead to designing specific project interventions that would ameliorate the condition of the communities.

Implementation Strategy

a) Small Group Approach

The Outreach Extension Centre would adopt the Small Farmer Groups (SFGs) approach to deliver agricultural extension services and rural development to smallholder farmers in the communities as an effective institutional device for lowering the delivery costs of these services, for reducing the expenses smallholder farmers incur in gaining access to those same services, and to markets, and for promoting small farmer self-development. Small farmer groups (SFGs), are also seen as a useful organisational mechanism for mobilising smallholder farmer collective self-help actions aimed at improving their own economic and social situations and that of the communities in model villages. Indeed, the benefits of using small group approaches for more efficient delivery of agricultural extension as well as other rural development services to smallholder farmers are now widely appreciated. From agricultural extension point of view, it will be much easier for change agent to deal with nucleated settlements either in the provision of improved technologies or communication since the development effort envisaged is through social groups which are usually cohesive and easier to work with. From the simple principles of small group dynamics, farmers tend to learn more quickly in small group situations where there is more face-to-face contact and therefore less room for misunderstandings; and decisions can be reached more quickly than in larger group situations. When small group membership is homogeneous - i.e., when members share some common bond, like location proximity, a similar income activity, or they come from the

same socio-economic background - then there is also less potential for inter-member conflict and consequently more solidarity.

b) Accessible Advice

Oloruntoba (2013) reported that Africa has lagged behind in harnessing the Information Communication Technology (ICT) potential for extension services and rural development. Hence, the use of ICT in agricultural extension services has become necessary because of low ratio of extension officers to farmers. The Centre will develop methods of using ICT's such as multimedia, video to reinforce extension services and improve farming. Information will be provided to farmers and extension officers in local languages through a dedicated website. The quality of information will be presented in a readily accessible means to farmers and actors to improve agricultural production. Again, the use of cell phones to network with farmers, input suppliers and extension advisors will be encouraged to keep the farmers up-to-date on improved agro-technologies.

c) Advocacy and Sensitisation

Relevant contacts are being made with several Non-Governmental Organisations and farmer-led initiatives to continuous advocacy and sensitisation visits to the villages in company of the District Head of Dutse; encourage them on the need to cooperate with the institution which will pave way for them to enjoy immense benefits from this relationship

Conclusion

The situation analysis of the rural communities around the Federal University Dutse in the Northwest Nigeria depicted that of peasantry with very low annual income, large household size, small fragmented lands, low education and very weak agricultural extension linkage. The effort of the University for establishing the Outreach Centre was to serve as remedial measures for the rural communities in terms of agricultural extension access on one hand, and on the other hand, bring good understanding with the host communities. Following the near-collapse of the supply-driven public agricultural extension system at different periods in Nigeria, the University Extension initiative appears to be the panacea in 'helping the farmers to help themselves'. However, the Outreach Centre has to cultivate effective partnerships and collaborations with other agencies to bring about the expected successes and provide opportunities for stakeholders to appreciate the university's contribution to extension services and rural development.

Consequently, to continue to be relevant, effective and efficient, the Outreach Extension Centre and extension personnel should be well acquainted with the problems of the farmers and rural dwellers. The success is by indentifying and simplifying the key problem areas and then dealing with it with full support from the University and other partners. In this circumstance, local experience of successes and failures will enable the extension administrators to continue to identify the most critical problems which may have varying degrees of importance at different levels.

Acknowledgement
The funding support for the Conference was provided by the Tertiary Education Trust Fund (TETFund), Federal Republic of Nigeria, Abuja was gratefully appreciated.

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ANAEROBIC CO DIGESTION OF CAFETERIA LEFTOVER FOOD AND TOILET WASTES FOR BIOGAS PRODUCTION AND KINETIC EXPERIMENT

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Abstract
Anaerobic digestion is a process in which microorganisms break down biodegradable substrates in the absence of oxygen. It can be used to treat varies organic wastes and recover bio-energy in the form of biogas, which contains mainly methane and carbon dioxide and this gas can be used for lighting and cooking.
Primarily the substrates phyisco- chemical properties (moisture content, ash content, total solid content, BOD and COD) where using standard methods. The result suggested that watt > pasta > Injera > bread > toilet waste interms of biogas yield.
In this work anaerobic digestion of cafeteria leftover food and toilet waste was carried out in a 5 L reactor (W8 anaerobic digester for a temperature range of 20-33^{o}C and initial pH of 4-9.During the experiments, the biogas production was recorded using water displacement method and by considering the ideal gas equation the concentration of methane was calculated. A maximum volume of 995.9ml was recorded at 30 day retention time at initial pH of 7 and at y ambient temperature condition.
The maximum cumulative biogas production was 4001ml at 25^{o}C and 10:90 toilet wastes to cafeteria leftover food.
The kinetic parameters of the anaerobic co-digestion were investigated at selected temperatures. The degradation rate constant was determined in temperature of 20, 25 and 33^{o}C.
A pseudo first order kinetic model was proposed for the anaerobic digestion. From Arrhenius equation the obtained values of activation energy and pre-exponential factor was 7262.279 J/MOL and 717.408J/MOL respectively.
Keywords Co-digestion Toilet waste Cafeteria leftover food Biogas Kinetic model

Introduction

Anaerobic digesters convert organic waste (agricultural and food waste, animal or human manure, and other organic waste), into energy (in the form of biogas). The benefits that the anaerobic digestion process provides are waste management, energy production, and fertilizer production

Waste management is very important in both urban and rural settings. Most industrialized parts of the world already have waste management systems, though they often can be improved with regards to environmental impact. Rural areas often lack sanitation or reliable waste management systems, and this is a highly valuable service for health and environmental reasons.

Co-digestion is simultaneous digestion of homogenous mixture of two or more substrates. Traditionally anaerobic digestion was single substrate, single purpose treatment. Recently, it has been realized that anaerobic digestion as such become more stable when the verity of substrates applied at the same time is increased.

Anaerobic digestion can provide energy to those who do not already have it, or can produce clean energy as an alternative to carbon-intensive energy production. Energy provided to those who do not already have such as people live in rural area and they are with different organic wastes enables them to accomplish more, and allows for a much higher quality of life.

The fertilizer by-product is another benefit that can add value to an anaerobic digestion system. Once a feedstock is consumed by the anaerobic digestion process, the leftover material can be used as a soil additive to enhance crop production. In rural settings, this fertilizer is best used locally or on-site of the anaerobic digester

Biochemical process of anaerobic digestion

Anaerobic digestion is a process of degradation of a substance in the absence of oxygen. There are four major steps of anaerobic digestion shown in the figure 1 and described in detail in the following section

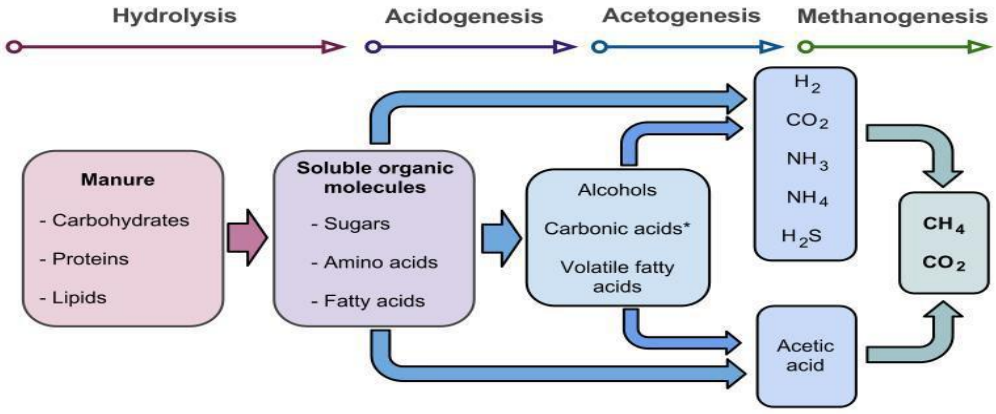

Figure 1.1: The anaerobic digestion pathway

Hydrolysis

The first step in the anaerobic digestion process, hydrolysis is the cleavage of chemical bonds by the addition of water. The digester feedstock may be made up of many different components and materials, and thus there are many different versions of hydrolysis; carbohydrates, fats, and

proteins are all broken down into smaller molecules by this initial step of anaerobic digestion.

Acidogenesis
Acidogenic bacteria degrade the products of hydrolysis into volatile fatty acids. Some hydrogen, carbon dioxide, and acetic acid are also produced, which will skip the Acidogenesis stage. Acidogenesis represents the portion of figure 5 in which bacteria produce acetate and butyrate (volatile fatty acids) from glucose

Acetogenesis
In the third step of anaerobic digestion, Acidogenic bacteria consume precursors and produce acetate (acetic acid). One example of this process is the consumption of glucose, given in equation 1.1.

$$C6H12O6 + 2H2O = 2CH3COOH + 2CO2 + 4H2 \text{----------} 1.1$$

Methanogenesis

The final step of anaerobic digestion is the formation of methane by bacteria called methanogens. For the most part, the biological process here is the breakdown of acetic acid, given in equation 2, though other forms of the reaction can also produce methane via anaerobic digestion.

$$CH3COOH = CH4 + CO2 - - - - - - - - 1.2$$

Statement of the problem
Even though different higher institutions are planning to generate biogas from leftover food, the high organic acid nature of cafeteria leftover food substrate is supposed to lower the biogas productivity. This need to be addressed by using this substrate as a main substrate or co-substrate with toilet wastes and formulating ratio at which better yield could be obtained is the first intention of this study.

At the same time, the biochemical digestion kinetics, which is important for biogas plant design, is not investigated for these specific substrates.

1.3 Objective

1.3.1 Genera objective
The General Objective of this Thesis is study of the Co-Digestion of Anaerobic Biogas Production from Cafeteria and Toilet Waste for design improvement.

1.3.2 Specific objective `

- To characterize phyisco-chemical properties of cafeteria leftover food and toilet wastes
- To investigate effects of operating conditions (temperature, initial pH and ratio of toilet wastes to cafeteria leftover food) for the anaerobic co-digestion on the yield of biogas
- To generate the reaction rate data and develop kinetic equation for biogas production from the anaerobic co-digestion process of these specific substrates

MATERIAL AND METHOD

3.1 Materials

All chemicals used in this study are analytical grades, obtained from Faculty of Chemical and Food Engineering and Faculty of Civil and Water Resource Engineering at Bahir Dar Institute of Technology, Bahir Dar University, pH capsules were used (for buffer solution preparation during pH meter calibration), Sodium hydroxide (0.1M, for pH adjustment), hydrochloric acid (0.1M, pH adjustment), tap water (as raw material for anaerobic co-digestion). Potassium dichromate solution sliver sulphate, ferrous ammonium sulphate solution, Ferro in indicator and Liquid detergent were used to characterize the substrate and the slurry parameters such as to determine the COD of substrates.

3.2 Equipment

Plastic glucose bags (for biogas sample handling), DO meter (to measure the dissolved oxygen in the sample before and after incubation), BOD bottles (for sample handling for COD and BOD determination), incubator (to maintain the sample at dark condition), Oven (for moisture content determination maintain the sample at constant temperature), Furnace (for ash content determination maintain the sample at constant temperature), pH meter(to measure the pH of the substrate), Sample holding plastics , 20 liter plastic digester(for anaerobic co-digester), glass tube airtight with one side(to water displacement volume measurement setup preparation), 0.5 inch plastic pipe(for biogas transport from anaerobic co-digester to water displacement setup), glass jar (for volume measurement during buffer solution), 0.1M of sodium hydroxide and hydrochloric acid preparation), quartz paint container (for water displacement setup preparation for biogas volume determination) and safety clothes such as eye glass, glove, nose mask and cleaning agents such as broom.

Experimental Methods

3.3.1. Sample analysis

The physical and chemical properties of the feed stock were evaluated before and after digestion using standard methods (ASTM D2974) for parameters analyzed includes: total solid content, total solid volatile content, ash content, moisture content and also biological oxygen demand (Winkler method) and chemical oxygen demand (Open Reflux method) were determined.

Experimental procedures

3.3.2. Substrate collection and preparation

Subsrstrate as a feed for the digester collected from Bahir dar Institute of Technology Student Cafeteria and from Dormitory toilets. The toilet waste was collected by diverting the toilet line from block No.61 at sampling time morning. The sample was collected by the expert who had good knowledge and experience about safety. At the end of diverged pipe there was portable sample collecting plastic material, which has sieve to pass the water and urine part through it.

After collecting enough amount of human waste it was transferred into the plastic handling equipment /baldy / and transported into the laboratories at which the experiment was conducted. In the same way the cafeteria leftover food was collected by the same expert and sample was collected by considering the presence of all food items such as Injera, bread, cooked pasta, cooked rice and onion peels. The sample was taken during lunch time because at this meal time all food items are included at students menu.

Prior to the commencement of the experiment, the cafeteria leftover food was thoroughly homogenized by manually to have particle size suitable for easy digestion and then mixed evenly with toilet wastes. The mixture used was a combination of cafeteria leftover food (0%, 10%, 30%, 50%, 70%, 90% and 100%) and toilet wastes (100%, 90%, 50%, 30%, 10% and 0%). This substrate was further mixed with water in a 1:1 m/v ratio to make final 4.3 liters slurry that was fed to anaerobic digester. The experiment allowed running for thirty days.

3.3.3. Experimental setup and description for temperature and waste ratio investigation

After characterizing the substrate anaerobic digestions experiments with two replicas were performed in five liter cylindrical shape digesters. The experimental setup is presented in figure 3.1.The substrate was introduced into the reactor 15 cm lower than the full height to avoid over flooding. The digester has many components which are described on the figure.

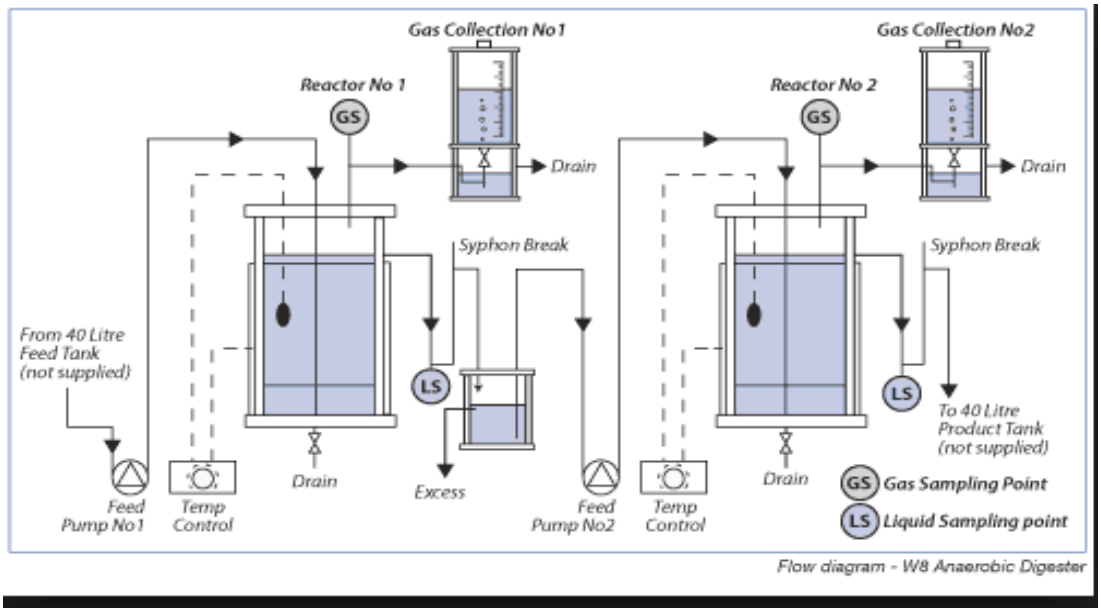

Figure 3.1: Experimental setup of anaerobic co-digestion for temperature and waste ratio effect investigation

The anaerobic digestion was conducted in anaerobic digester in batch wise mechanisms. The collected and prepared and weighted substrate was feed into the digester by taking care from contact with bare hand by wearing gloves, masks and eye glass by mixing with equivalent amount of water.

After the substrate feed in to the digester then mixed with clean wooden material to make uniform slurry inside the digester. Then porous non digestible plastic made materials were added in to the digester, because it is known that anaerobic digestion takes place due to the presence of microbes and the microbes inside the digester needed solid material with it and act accordingly, So to increase the activity of microbes by increasing the exposed area to the substrates.

The digester cover was closed by insuring the absence of gas leakage by using sealants. Then open the safety valve to remove oxygen already presented inside the digester for twenty four hours.

After a day the valve closed because intermediate product of the digestion such as volatile material and others will develop and will escape. In the experimental setup there is another five liter

cylindrical gas collector, the gas collector was first filled by water and seal the top cover by using sealants and check whether there is water leakage or not at the bottom, after it becomes ok open the bottom valve through which the water is displaced when biogas developed /collected/ inside the collector. When the bottom valve open there is no water leakage unless an external disturbance is applied /biogas developed and collected at the top layer of water inside the gas collector/ due to density difference it applied vertical load on water upper layer the corresponding amount of water displace through the bottom valve.

The biogas which is generated in the digester transfer to the gas collected cylinder with the glucose valve from the top of the digester to the bottom of the biogas collected cylinder.

Finally the temperature was set by pressing the upper and lower key by holding the set menu key at required temperature. The daily biogas generated amount determined /recorded/ by reading the height difference on the glass collector cylinder occupied by daily product /biogas/. The volume daily produced biogas was determined and summing all the daily volumes for the thirty day retention time to get the total volume of biogas generated for on batch anaerobic digester from a specified amount of substrate.

3.3.4 Initial PH effect on biogas yield

3.3.4.1. Experimental setup and description

In this experimental work there were two basic setups: Anaerobic co-digestion setup and water displacement setup for biogas volume determination by using locally available materials.

Anaerobic co-digestion setup was prepared by taking 20 liter plastic digester which was bought from local market. The cover of the plastic digester was drilled by using hot metal rod with the diameter of the pipe, which is 0.5 inch and insert the pipe in the drilled hole with force fit and then we made it airtight using Amir. Water displacement setup was prepared by using the materials which is listed in the material section. The quartz paint container was collected from our institute store and the quartz paint container was drilled at the position 10 cm bellow from the top of it with the diameter of water discharged plastic pipe, 0.5 inch.

The quartz cover was drilled with glass tube diameter by using hot knife. Then we filled the container with tap water up to the drilled position meanwhile the glass tube was fully filled with water.

The plastic pipe from the top of the plastic digester was inserted inside the water filled glass tube up to a random height. Finally it was checked by filling of water in the quartz paint container up to over flow position.

Figure 3.2: Experimental setup of anaerobic co-digestion for initial pH effect determination

Result analysis procedures

3.4. Kinetic Model of Anaerobic Digestion

3.4.1 Basic Input-Output Kinetic Model Anaerobic Co-digestion

The purpose of this model is not to create entirely compressive model that takes all factors into account and predict biogas output to very high level of precision. It cans however biogas output over time.

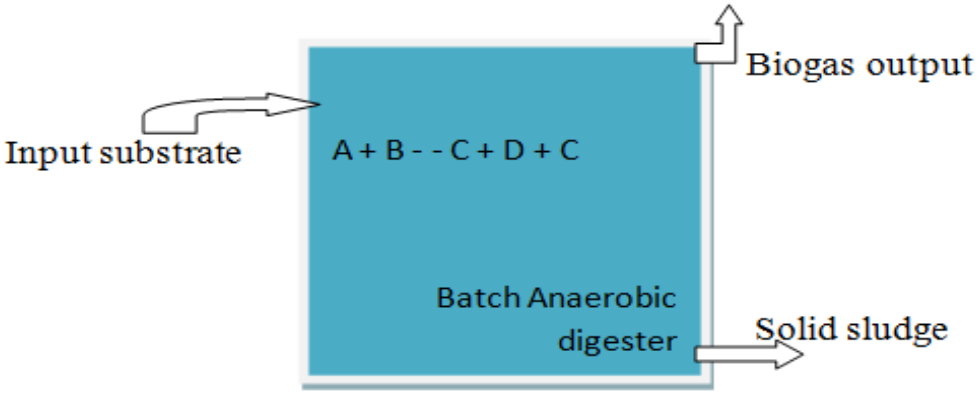

Figure 3.3 Basic input-output model of anaerobic batch reactor

3.4.2 Model assumptions

The initial assumptions of this model are given below:

- ✓ Production of intermediate species is negligible (the reaction is a one step)
- ✓ The volume of anaerobic digester is constant, 5 liter.
- ✓ Ideal bacterial conditions
- ✓ Input substrate consist only C, H, N and O
- ✓ Products of reaction include only CO2, CH4 and NH3

In the simplest case of a batch anaerobic digester, reactants fat, carbohydrate and protein are put into the digester in batch. Once in the digester, protein, fat and carbohydrate break down into products CO2, CH4 and NH3 at a rate based on reaction coefficients.
Some of input substrates don't break down all the way, and leave through the outlet - the amount that leaves instead of being broken down depends upon digester size, residence time of the feedstock and other parameters.

If the fractions of fat, protein and carbohydrates are known, the theoretical methane yield can be determined using the Buswell formula.

$$CnHaObNc + \left(n - \frac{a}{4} - \frac{b}{2} + \frac{3c}{4}\right) H2O = \left(\frac{n}{2} - \frac{a}{8} + \frac{b}{4} + \frac{3c}{8}\right) CO2 + \left(\frac{n}{2} + \frac{a}{8} - \frac{b}{4} - \frac{3c}{8}\right) CH4 + c\text{NH3}$$

3.6

And also Hojlund Christensen investigated the average composition of organic compounds as shown in table 3.2:

Table 3.2: Average composition of organic compounds

Compound	Elemental composition
Fat	$C_{57}H_{104}O_6$
Protein	$C_5H_7NO_2$
Carbohydrate	$C_6H_{10}O_5$

Let me assume the input substrate is a single compound by summing up the elemental composition of each compound, listed in table 3.2. So the input substrate has the molecular formula: $C_{69}H_{121}O_{13}N$. Then

$n - \frac{a}{4} - \frac{b}{2} + \frac{3c}{4}$ =32.75 stoichiometry coefficient of water

$\frac{n}{2} - \frac{a}{8} + \frac{b}{4} + \frac{3c}{8}$ = 7.625 stoichiometry coefficient of carbon dioxide

$\frac{n}{2} + \frac{a}{8} - \frac{b}{4} - \frac{3c}{8}$= 46 stoichiometry coefficient of methane

c =1 stoichiometry coefficient of ammonia

Let me rewrite the reaction equation

$$C69H121O13N + 32.75H2O - 7.625CO2 + 46CH4 + \text{NH3}\text{------}3.7$$

This reaction equation is not balanced. The above reaction equation was further balanced by using general reaction equation balancing approach. The balanced reaction equation is given bellow:

$$C69H121O13N + 33H2O - 23CO2 + 46CH4 + \text{NH3}\text{-----}3.8$$

The biochemical reaction is balanced and can be applied to any input with known relative ratios of carbon, hydrogen, oxygen and nitrogen. The model assumes that these elements are the only components of the feedstock.

Table 3.3: Balance of biochemical reaction used in this model

Components	**Left**	**Right**
Carbon	69	23+46=69
Hydrogen	121+66=187	46*4+3=187
Oxygen	13+33=46	23*2=46
Nitrogen	1	1

The rate law of the anaerobic digestion for forward reaction can be expressed by equation.
Based on the above assumptions

$$-\text{rC69H121O13N} = K\,[C_{69}H_{121}O_{13}N]^{n}\,[H_2O]^{P}\text{-----}3.9$$

Where $[C_{69}H_{121}O_{13}N]$ is the concentration of organic waste and $[H_2O]$ that of water, n is order of anaerobic digestion with respect to organic waste and p is order with respect to water and K is the equilibrium rate constant. However due to the high water to total volatile ratio, the change in water concentration can be considered as constant. Even if we used 1:1(m/v) organic waste to water ratio, the average moisture content of the organic waste is 42.226% and the average volatile content of organic waste is around 17%. As a result the change in the concentration of water is almost constant. Hence, the reaction obeys pseudo first order kinetics. Finally the rate expression can be written as:

$$rC69H121O13N = \frac{d[C69H121O13N]}{dt} = K' [C_{69}H_{121}O_{13}N] \quad \text{---------3.10}$$

where k' is modified equilibrium rate constant, $k'=k [H_2O]^P$.

The initial concentration of organic waste was determined based on the limited substrate which is total volatile content of organic waste. The initial concentration of organic waste at $t=t_0$, $[C_{69}H_{121}O_{13}N] = [(C_{69}H_{121}O_{13}N)_0]$ and at t=t, $[C_{69}H_{121}O_{13}N] = [(C_{69}H_{121}O_{13}N)_f]$. Then, the conversion of the organic waste ($X_{C69H121O13N}$) can be developed from mass balance as shown equation 3.11 below.

$$X\,(C69H121O13N) = 1 - \frac{[(C69H121O13N)f]}{[(C69H121O13N)0]} \text{---------3.11.}$$

From substitution of equation 3.11 in equation 3.10 and Integration and rearrangement of equation 3.10 gives equation 3.12.

$$-\ln\left(1 - X\,(C69H121O13N)\right) = K' * t \text{ ------3.12}$$

$$K' = A * e^{-\frac{E}{R*T}} \text{ ---------- 3.13}$$

The concentration of the product/ substrate can be calculated from ideal gas equation as shown in equation 3.14 and 3.15.

$$X(C69H121O13N) = 1 - \frac{PA}{R*T*CA0} \text{ ---------3.14}$$

Daily partial pressure of biogas (methane) was calculated by using equation 3.15 by taking literature value density, $0.93 g/cm^3$ (Basic Data on Biogas, 2nd edition, Sweden, 2012) of biogas and daily height lowered in gas collector cylinder.

$$\text{Partial presure} = \text{density of biogas} * gravity * height \text{ ----- 3.15}$$

4.0 RESULTS AND DISCUSSION

4.1 Substrate Characterization

Substrates for the experiment were obtained from Student cafeteria and Student dormitory toilets. All samples prepared were determined for their phyisco-chemical properties before charged into the anaerobic bio-digester. A simple kinetic model with lamped parameters was developed and validated with experimental results.

Types of leftover meal in the cafeteria considered in this study are: Injera, bread, cooked pasta, cooked rice, onion peels and marmalade. The composition of leftover food from student cafeteria is presented in table 4.1.

Table 4.1: Components present in cafeteria leftover food

Component	Composition (%)
Injera	50
Bread	20
Cooked pasta	13.6
Cooked rice	12
Onion peels	3.5
Marmalade	0.9

4.1.1 Moisture content

The moisture content of the substrates obtained follow the protocol stated in section 3.3.1.2 is presented in table 4.1. As it can be seen in the table watt has the highest moisture content while toilet waste has the lowest moisture content. From our input substrates relatively the highest biogas yield can be achieved from toilet waste substrates due to its high total solid content. It is known that substrates which are used as a biogas source should have enough amounts of biodegradable biomass, so high solid content implies relatively much amount of biodegradable content of substrate.

Table 4.1: Moisture content of wastes

Sample		Sample mass (gram)	Moisture content (%)
Cafeteria wastes	Bread	68.60	41.23
	Injera	64.51	38.60
	Watt	6.58	72.810
	Pasta	32.31	33.86
Toilet waste		11.57	24.63

So substrate with high total solid content have high content of the free fatty acid source as a result the substrates can be priorities on their biogas potential as follow: toilet wastes. > Pasta > Injera >bread> watt.

But further ultimate analysis such as volatile content determination is needed to strictly predict the biogas potential from the total solid content of substrate, because from this fraction of total solid content digestible matter will be small.

4.1.2 Volatile solid content

For the determination of the volatile solid content of the substrate required amount of substrate sample was burned in a furnace at 550^{o}C for two hours. The mass of the ash was measured using digital balance with precision of two decimal places. The entire volatile solid content is assumed to escape by this two hours burning and the escaped percentage of mass represents the volatile solid content determined by subtracting the ash content from total solid content of the sample.

Table 4.2: Volatile content of different wastes

Sample		Sample mass (g)	Total volatile Content (%)
Cafeteria wastes	Bread	40.32	13.25
	Injera	39.61	18.08
	Watt	1.79	31.41
	Pasta	21.37	20.27
Toilet waste		8.72	2.51

The composition of the substrates interms of total volatile content is presented in table 4.2. As it can be shown watt has high total volatile content; while toilet waste has low total volatile content. Since total volatile content represents the biodegradable component of the sample during anaerobic digestion; we can arrange the substrates based on their biogas potential. It can be arranged based on their biogas producing potential: watt > pasta > Injera > bread > toilet waste.

All compounds are decomposed to simple soluble molecules and all intermediate products such as alcohols, carbonic acid, and volatile fatty acids produced at acids produced at acido- genesis stage of anaerobic digestion is from volatile content of the substrate.

4.1.3 BOD and COD of substrates

Table 4.3: BOD and COD of the substrate used for biogas production

No.	HW to LOF Ratio	BOD [mg/l]	Literature value [mg/	COD(mg/l)	Literature value [mg/l]
1	100:0	38	37-434	2590	610-18,550
2	90:10	45	>>	2350	>>
3	10:90	43	>>	3500	>>
4	50:50	35	>>	3150	>>
5	0:100	41	>>	3750	>>

Ratio is based on toilet waste: leftover food

Source: for literature values J.Natan.sci.Coun.Sri lanka, 1993

Similarly the BOD and COD of the substrates at fed ratios were measured and presented in table 4.2. As it is seen in table the value of the BOD and COD has seems no direct relationship with the waste ratios. This implies both wastes have nearly similar biological oxygen demand. When cafeteria leftover food and human waste compared with industrial wastes the value of BOD is small, this implies that the sample has low amount of microbes. The values of COD are moderate when it is compared with industrial wastes.

4.2. Effect of operation conditions on biogas yield

Table 4.4 Effect of temperature and feed ratio on biogas yield at retention time of 30 days

Run	Temperature(oC)	Ratio	Volume of biogas (ml)	Replica Volume of biogas (ml)	Average biogas volume [ml]
1	25	0:100	5628..12	4982.52	5305.35
2	20	10:90	1932.16	1901.97	1917.065
3	25	10 :90	4017.54	3985.08	4001.00
4	33	10:90	2226.425	2161.752	2194.0885
5	20	30 :70	1546.64	1718.00	1632.32
6	25	30: 70	3687.28	3345.00	3516.14
7	33	30:70	1028.92	987.80	1008.36
8	20	50:50	1328.36	1513.36	1420.86
9	25	50:50	3486.945	3396.375	3441.66
10	33	50 :50	3351.09	2467.945	2909.52
11	20	70:30	2118.62	1938.26	2028.44
12	25	70:30	2113.43	3783.62	2948.525
13	33	70 :30	1028.92	987.82	1008.37
14	20	90 :10	966.08	966.88	966.44
15	25	90:10	3392.747	2177.41	2785.0785
16	33	90:10	2245.425	1343.455	1794.44
17	25	100:0	2118.62	1938.26	2028.44

Ratio is based on toilet waste: cafeteria leftover food

The experiment was conducted in replica of two. Finally the average value of the two out puts was written at the last column.

The effect of temperature on the yield of biogas at different substrate ratios was presented in table 4.4. As it is can be seen in table 4.4, the cumulative biogas produced at specified temperatures from each ratio is higher at 25^{o}C. From the table it can be also notice that the ratio of toilet to cafeteria leftover food has a maximum biogas yield at thirty day retention time.

The maximum average volume of biogas produced at 25^{o}C; 10: 90 toilet to cafeteria leftover food ratio for thirty day retention time from 2.15kg solid waste is 4001ml.The experiment from only cafeteria and toilet waste was conducted 25^{o}C for comparison of the biogas potential and it was observed from the figure that the cumulative biogas volume from cafeteria leftover food is higher than the toilet waste alone.

4.2.1 Effect of temperature on daily biogas yield

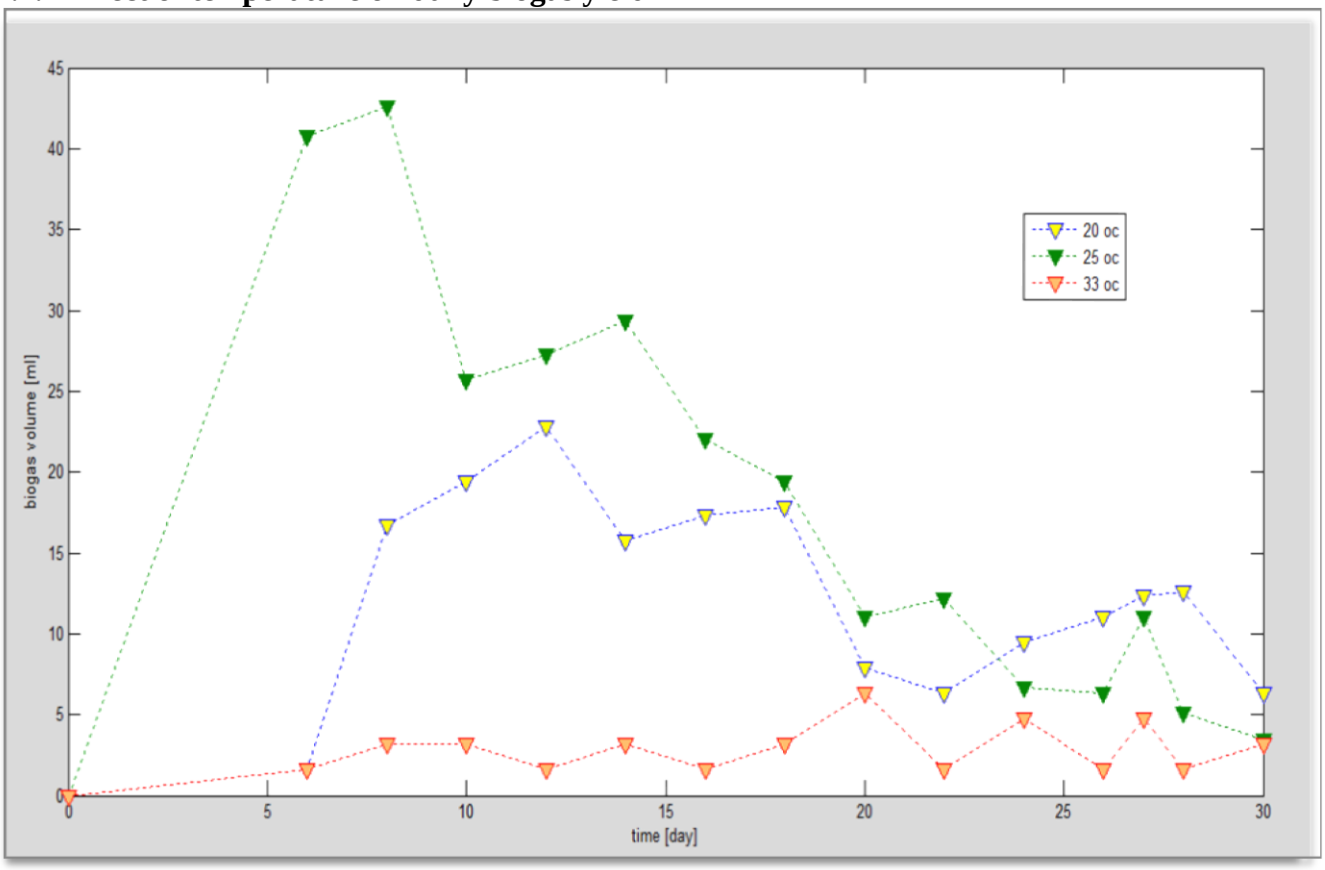

Figure 4.2: The effect of temperature on the biogas yield at 10:90 (toilet to cafeteria).

The effect of temperature on daily biogas yield was investigated at on three different temperatures in mesophlic digestion conditions and at optimum substrate ratio of thirty day retention time. The yield of biogas is presented in figure 4.2 as it can be seen in the figure; the anaerobic digestion is strongly dependent on temperature. At 20^{o}C the yield of biogas was lower and as the temperature increase from 20^{0}C to 25^{0}C the biogas yield is increased from 1917.065 to 4001 ml. This implies that the kinetics and thermodynamics of microorganisms inside the digester is very much sensitive to temperature. The cumulative biogas yields from 10:90(m/m) of toilet and cafeteria wastes are 1917.065 ml, 4001ml, and 1194.088ml at 20^{o}C, 25oC and 33^{o}C respectively.

4.2.2. Effect of Substrate Ratio on Biogas Yield

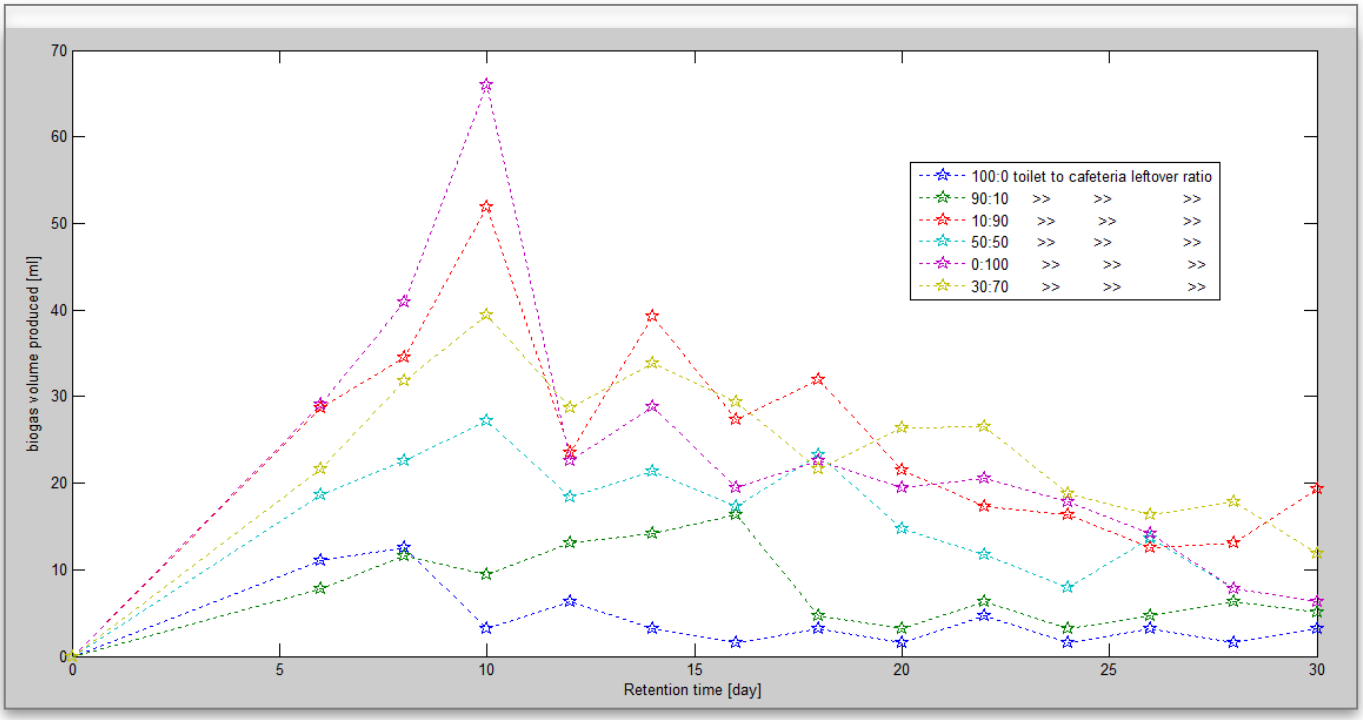

Figure 4.3: Effect of substrate ratio on biogas yield: t= 25^{o}C, initial pH=7

The effect of substrate ratios on daily biogas yield was investigated for a wide range of substrate ratios in wet base at a temperature of 25^{O}C and retention time of thirty day. As it can be seen in the figure anaerobic digestion is strongly dependent on the amount of cafeteria leftover food in the sample, as a addition of cafeteria leftover food with toilet waste increase the yield of biogas production. This is due to the low total volatile content of toilet wastes when compared with cafeteria leftover food (see table 4.2). The average cumulative biogas yields at 25^{O}C for thirty day retention time is 2028.44ml, 2785.0785ml, 3441.66ml,3516.66ml, 4001ml, and 5305.l35ml for the range of substrate ration of (toilet waste to cafeteria leftover food) 100:0, 90:10,50:50,30:70,10:90 and 0:100 respectively.

4.2.3. Effect of Initial pH on Biogas Yield

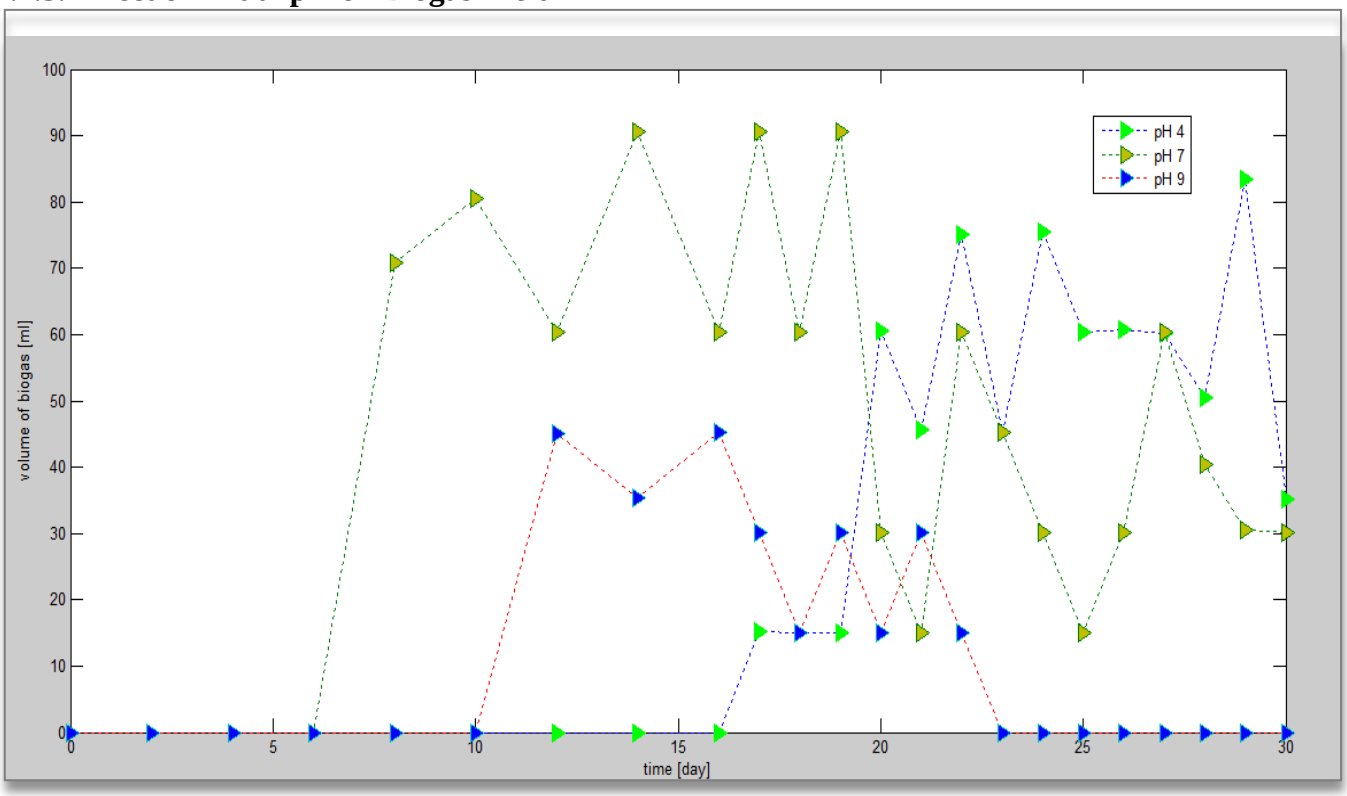

Figure 4.4: Effect of Initial pH on Biogas production: Substrate ratio =10:90, temperature =20^{O}C

The daily biogas produced from organic fraction of toilet and cafeteria waste for different solution pH, at ambient temperature was presented in figure 4.3. It is noted that the biogas production of toilet and cafeteria wastes was performed without inoculums effect. The production is maintained until the 30 days. Interestingly it was observed that the biogas production starts at different for each pH treatment. As it can be seen the production starts after nine days for pH = 4 treated substrate, after five days for pH=9 treated substrate and after four days for pH=7 treated substrate. This is in agreement with results reported by Vedrenne et al, 2005 at similar solution pH of 4, 5.5 6, 7 and 9. This demonstrates that the initial pH of the substrate is deliberately changes the activity of microorganism is retarded, because the population of bacteria was affected that is why the yield of biogas decreased. As seen from figure 4.3 the lag time at each pH indicates the effect of pH on microbe's population growth and activity. It is also clearly seen that the higher the pH the shorter is the reaction time to complete the reaction. So if the acidity or basicity of substrate is far from optimum value they take much time for adaption and start their digestion activity. After digestion the pH of the slurry was 6.02, 7.23 and 7.62 for initial pH of 4, 7 and 9 respectively. This means that there was ascended of pH made the environment favorable to digestion.

The final volumes of biogas from 2.15 kilogram of cafeteria and toilet wastes are 995.9 mL, 694.14 mL 256.49 mL corresponding to the reaction condition of pH =7, pH = 4 and pH = 9 respectively. This suggested that pH 7 is an appropriate start up condition for anaerobic co-digestion of leftover cafeteria and toilet waste.

4.2.4 Significance test for correlation

Table:4.5 **Tests of Between-Subjects Effects**

Dependent Variable: volume					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26100895.836[a]	14	1864349.703	8.886	.000
Intercept	152327176.566	1	152327176.566	726.015	.000
Temp	17941888.299	2	8970944.149	42.757	.000
Sub	2409975.252	4	602493.813	2.872	.060
temp * sub	5749032.285	8	718629.036	3.425	.019
Error	3147191.928	15	209812.795		
Total	181575264.329	30			
Corrected Total	29248087.763	29			

a. R Squared = .892 (Adjusted R Squared = .792)

The significance of temperature and substrate ratio was presented in table 4.5, which is the output of SPSS version 20. From the significance value we can see both temperature and the interaction of substrate ratio and temperature are significant at 5% level while substrate ratio is significant at 6% level.

4.3. Determination of Kinetic Parameters

In this work the kinetic data was collected by volume measurement of the daily biogas volume using water displacement method, which can provide real time monitoring of the reaction. The biogas volume difference gives an indication of the conversion of volatile content fraction of organic compound in to methane, carbon dioxide and ammonia.

The conversion (X %) of methane used in this work was monitored by measuring the volume of biogas at the specified time and varies temperatures based on ideal gas equation and the result of kinetic parameters was reported as follows:

4.3.1 Rate Constant, Activation Energy and Pre-exponential Factor Determination

It was considered that the digestion is occurred in liquid phase and it is supposed microbes are used to initiate the digestion for the formation of methane during the course of reaction. Table 4.5 represents the fractional conversion of volatile content fraction of organic compounds in digestion time of 0-30 days. The digestion temperatures were 20, 25 and 33^{O}C. Those temperatures were selected since the reaction condition is mesophlic and from section 2.2.2 mesophlic temperature range is 20-45^{o}c. the lower temperature level was selected to see the effect of temperature at this minimum temperature of the mesospheric digestion condition. On one hand the upper level of temperature 33^{O}C is limited to the maximum temperature Bahir dar city found. This is to predict the biogas yield that we can get from installed digesters around the city since they have no temperature control mechanism with their design.

The value of rate constant was determined from the plot of $-\ln(1 - X_{me})$ versus time. The result is presented in figure 4.5. As it can be seen the plot yields a straight line with correlation coefficient from 0.932-0.964 for the three (20, 25, 33 ^{O}C) temperatures considered in this work.

The reaction rate constant (K') with a lamp parameter model is obtained from the slop of plot of $-\ln(1 - X_{me})$ versus time. The values are found to be 0.0029-0.0409 day^{-1} for the range of temperature

considered. This suggests that first order kinetics can be used to describe methane generation of cafeteria leftover food and toilet waste (figure 4.5). The rate constants at each temperature and their corresponding correlation coefficient are listed in table 4.6. The rate constants represent the measure of biodegradation rate. The higher of rate constant value, the higher the biodegradability of the digester.

Table 4.5 Methane formation conversion at temperatures 20, 25, and 33^{o}c

Digestion time	X_{me}			$-\ln(1-X_{me})$		
	20^{o}C	25 ^{o}C	33^{o}C	20^{o}C	25 ^{o}C	33^{o}C
0	0	0	0	0	0	0
2	0.10	0.161	0.012	0.105	0.176	0.012
6	0.17	0.371	0.0304	0.186	0.463	0.0308
8	0.246	0.458	0.0456	0.282	0.613	0.0466
12	0.271	0.539	0.0517	0.316	0.774	0.053
16	0.298	0.565	0.0608	0.353	0.832	0.0627
18	0.344	0.607	0.064	0.422	0.934	0.066
24	0.362	0.677	0.07	0.449	1.13	0.0725
26	0.377	0.697	0.0822	0.473	1.19	0.0858
28	0.393	0.72	0.085	0.499	1.27	0.0888
30	0.407	0.739	0.0914	0.523	1.34	0.0958

Table 4.6 Reaction rate constants at the given temperature

Temperature (K)	K'(1/day)	R^2
293	0.0159	0.932
298	0.0409	0.964
306	0.0029	0.941

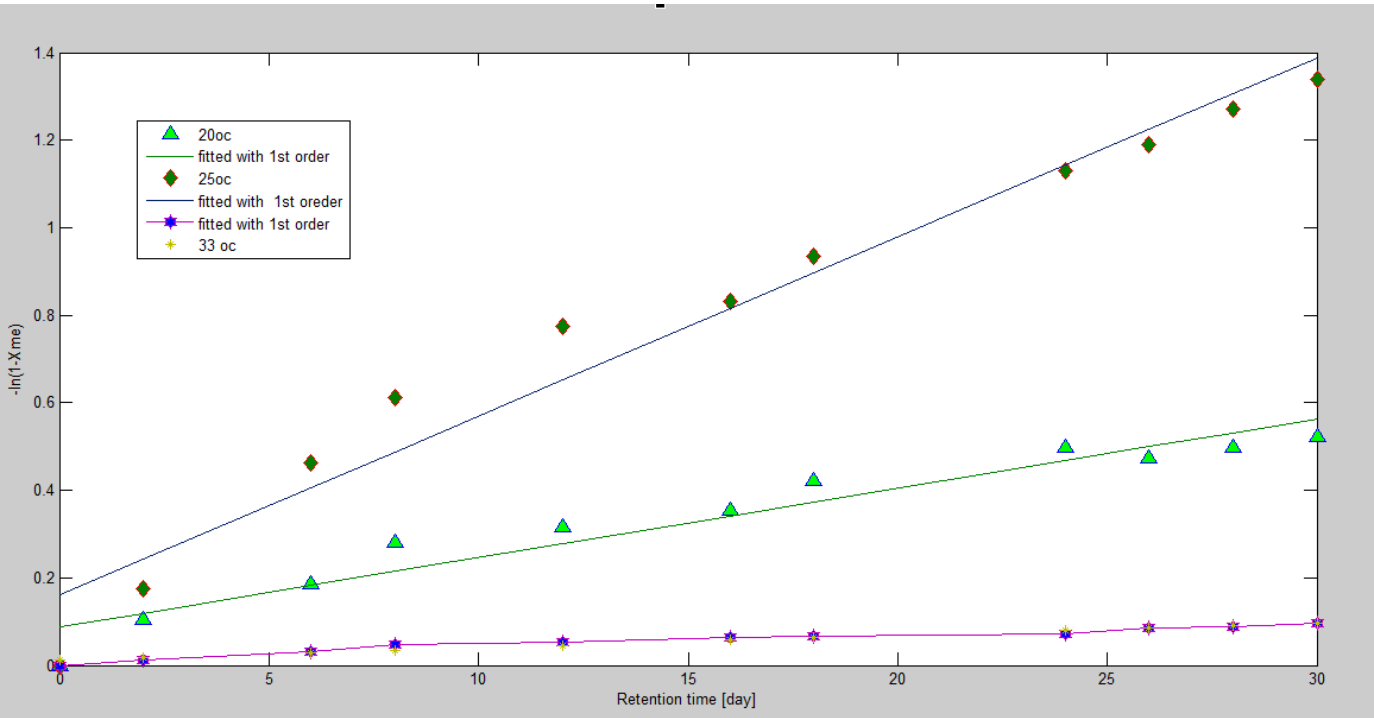

Figure 4.5: Plots of –ln (1-X_{me}) versus time [day]

4.3.1.1. Michaelis –Menten model

Even though there are many chemical and physical reactions takes place in anaerobic digestion process, in four most important steps for biogas production many intermediate products due to biochemical transformation reaction. But here the whole system is lumped to one step reaction as described in the above sections. In section 4.3.1 we tried to investigate and develop the model and validate the model by experimental data generated from the laboratory.

Further we fit the experimental results with Michaelis –menten equations and the relation of microbial population with methane product was investigated. Michaelis – menten developed that the rate of product formation is proportional to microbial growth.

$$r = \frac{dCp}{dt} = rmax * \frac{C\ CH4}{Km + C\ CH4} - - - - - - - - 4.3$$

The values of kinetic parameters were estimated by conducting experiment and generating concentration –time data. The reaction rate data for the corresponding concentration–time data was generated by differentiated concentration –time data by using numerical methods. This method was used because of the data points in the independent variable is equally spaced. The result plotted graphically as shown at figure 4.6, so that the validity of kinetic model was tested and kinetic parameters were estimated. As it is shown in figure 4.6 the value of rate constant was determined from the plot of [CH4]/Reaction rate versus [CH4] plotting yield straight line equations with goodness of fit (correlation coefficient) ranging from 0.932-0.964 at different temperatures with slope (Km) ranges 0.0667-1.601 day^{-1}.

This figure shows that first order kinetics can be used to describe methane generation of cafeteria leftover food and toilet waste (figure 4.5). The rate constants at each temperature range from 0.08-1.565 and their corresponding correlation coefficient are 0.928-0.993 listed in table 4.7.

The rate constants represent the measure of biodegradation rate. The higher of rate constant value, the higher the biodegradability of the digester. We can see in the table the degradation rate of substrates is highly depending on temperature. The interaction of microbe with substrate is higher at 25^{o}C when compared to at 33^{o}C. And the initial concentration of microbes in was also following the same trend as substrate microbe's interaction rate.

Table 4.7 kinetic constants and correlation coefficients

Kinetic model	Temperature (^{o}C)	Reaction rate constants	Correlation coefficients
Michaelis – menten model	20oc	rmax=0.15, km=1.106	0.937
	25oc	rmax=1.565,km=1.601	0.929
	33oc	rmax=0.08,km=0.667	0.993

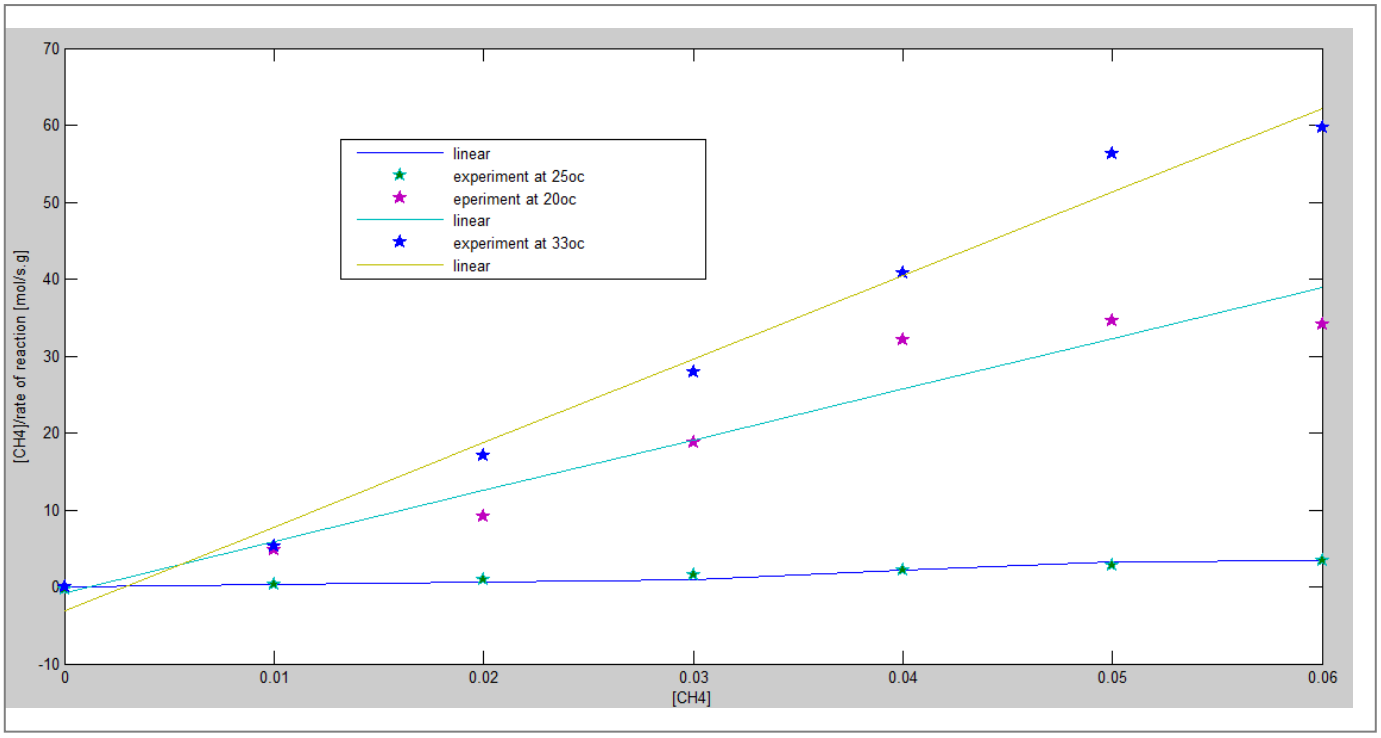

Figure 4.6: Formation of methane vs. biodegradation rate with methane concentration using Monod model

The activation energy for the anaerobic digestion reaction was calculated using Arrhenius equation 3.12 from the reaction rate constants shown in table 4.6. As it is shown in figure 4.6 the correlation coefficient (R^2) 0.993 indicates a good linearity between lnK' and 1/T in the temperature range of 20 - 33^{o}C. The value of activation energy and pre-exponential factor from figure 4.7 was 7262.279 J/ MOL and 717.408 J/MOL respectively. Therefore, the Arrhenius equation for the reaction rate and the reaction temperature (20 -33^{o}C) could be written as equation 4.1 and by substituting the slope and the intercept it can be written as equation 4.2.

$$K' = Ae^{-\frac{E}{RT}} \gg \ln K' = \ln A - \frac{E}{RT} - - - -4.1$$

$$\ln K' = 8.643 - 873.5 * \frac{1}{T} - - - - - -4.2$$

The activation energy for the anaerobic digestion of diluted labaneh whey for biogas production with temperature range (32-37^{o}C) was 5242.333 J /MOL [29].

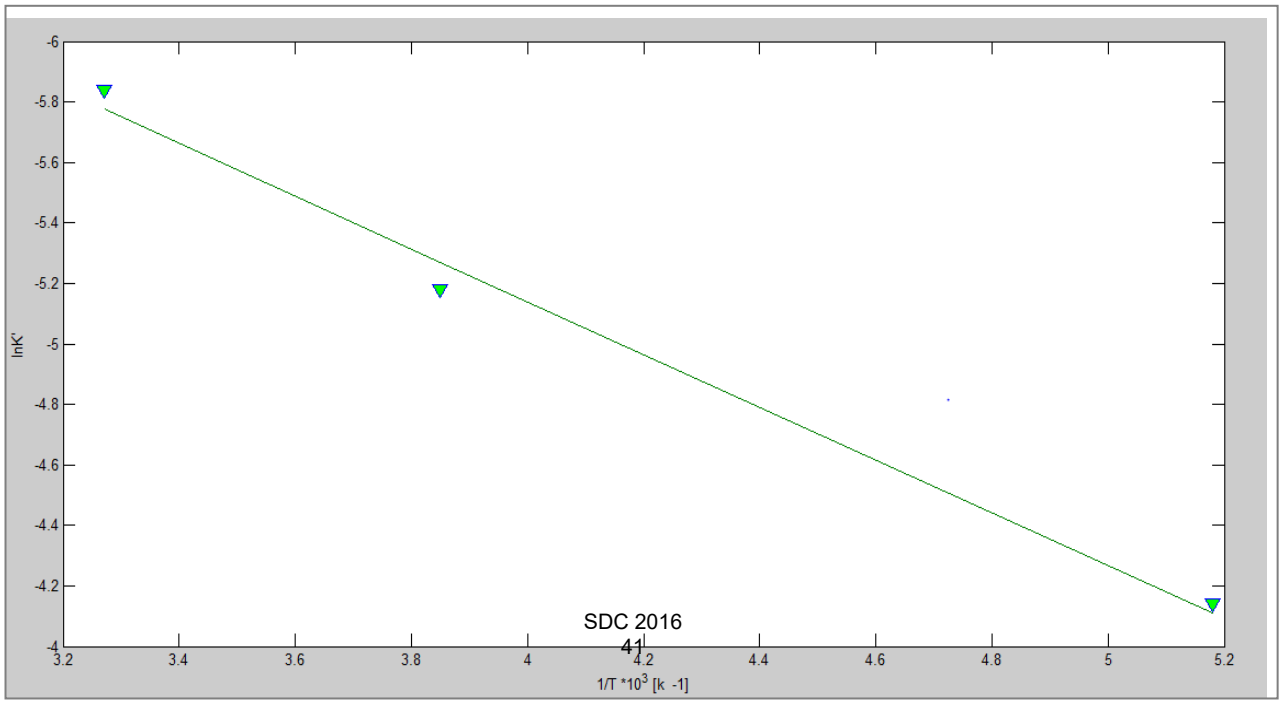

Figure 4.8: Plot of lnK' versus 1/T for anaerobic co-digestion

In this work, the activation energy obtained for the anaerobic co- digestion was higher than the value listed in the literature (Vedrenne et al, 2005).

5.0. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Biogas production from cafeteria leftover food and toilet waste was studied in 5 liter anaerobic digester. The substrates used as an input for the experiment were categorized and prioritized according to their total volatile content for biogas yield potential as: watt > pasta > Injera > bread > toilet waste.. This is based on the total volatile content.
The value of the digestion parameters: Cafeteria leftover food to toilet waste ratio 9:1, and digestion temperature 25^{o}C for 30 day digestion retention time was investigate to give the maximum conversion 74 % within the given range of parameters. According to this study the highest amount of biogas (4.001liter) was produced from 0.215kg of toilet waste and 1.95 kg of cafeteria leftover.

The kinetic parameters were determined by generating the conversion of methane at different reaction conditions from the volume of biogas generated. Temperatures: 20, 25, and 33^{o}C were used to study the temperature dependency of rate constants and these constants were determined at each temperature. The values of activation energy and pre-exponential factor were determined by fitting the reaction rate constants at different temperatures in Arrhenius equation. From Arrhenius equation the obtained values of activation energy and pre-exponential factor were 7262.279 J/MOL and 717.408J/MOL respectively. Then it was found that a pseudo first order kinetic model was proposed for anaerobic co-digestion of cafeteria and toilet wastes.

5.2. Recommendations

This thesis work investigates the possibility of employing volume measurement method of monitoring digestion progress for anaerobic co-digestion reaction. According to all the results and observations, the key findings in this thesis led to the following ideas for further considerations:

1. Although the pseudo first order reaction kinetics was proposed by monitoring the methane concentration by volume measurement and methane concentration using ideal gas equation, study the methane concentration profile for the digestion progress using biogas analyzer leads to the general understanding.
2. The temperature effect at thermophilic anaerobic condition should be done to compare the yield and biogas quality.
3. The effect of digestion retention time on biogas yield should be done further beyond 30 days.

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Assessment of natural and planted mangrove forest structures in selected sites in Central Visayas, Philippines

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Abstract

The prevalent destruction of mangroves with subsequent loss of essential services has encouraged many to increase the number of mangrove restoration and rehabilitation projects. Mangroves are example of dynamic ecosystems, consequently, there is a need of continuous learning for rebuilding a mangrove area. In this study we compared the species composition and diversity of natural and planted forests in two areas. Sixty plots were randomly established using quadrat sampling technique (10m x 10m) to identify, record and measure the ecological characteristics of natural and planted forests in the study area. In terms of number of species identified, natural forests revealed higher than planted forest both in Polo, Tanjay and Olango Island (11 and 9, respectively). The diversity index of Olango Island (*H'*= 0.62) and Polo, Tanjay (H'=0.89) both showed low value. *Rhizophora stylosa* dominated in both areas with an importance value of 194.8%. Therefore, these recorded values may support proper forest sustainable management and protect mangrove ecosystems.

Bio-fracturing Soil Model Using Fungus' Mycorrhiza to Anticipate The Water Shortage at Jatinangor Volcanic Aquifer, West Java, Indonesia

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ABSTRACT

Jatinangor District is located in Sumedang, West Java, at the southeast of the mount manglayang. Geologically, Jatinangor region is dominated by the results of the young volcano deposits like sand tuffaceous , breccias, and lavas which partly came from Mount Tangkubanperahu and partly from Mount Tampomas. The region's aquifer system is a volcanic deposit aquifer that consist of matrix supported breccia and laharic breccia . The high Level of weathering resulting in thick soil covering the aquifer with the maximum depth of 10 meters. The covering soil has low permeability which is 0,0003 cm/minute. This is considered low permeability. This condition decrease the water's ability to fill in the aquifer. The massive development of the area also affects the decrease of recharge area. This study aims to assess the feasibility to create the artificial recharge area with producing biofracture. Artificial recharge area is made by growing the fungus in the roots of plants around Jatinangor to do a symbiotic association with the roots of plants (ectomycorrhiza) so that the plants are stimulated to extend the reach of roots that can fill in the aquifer down below using their macropores. This research was conducted with hydrogeology and geomorphology study approach to determine the suitable areas for making artificial recharge. The results obtained from this study is the zonation map Jatinangor region that contains areas that are suitable and feasible to be used as artificial recharge area. This study is expected to be used as a benchmark for researchers, especially academics in the region in order to further development of artificial recharge.

Keywords: Artificial recharge, Biofracturing Fungus Mycorrhiza, Jatinangor

I. Introduction

Jatinangor is located in 6°52'30"-7°00'00" of south latitude and 107°45'00"-107°52'30" of east latitude. Physiographically, This area lies on the border between The Sumedang Regency and Bandung City. High population growth in this region resulted in a high population density which is around 4,270 people / km^2. The condition leads to the increase of water use which is not matched with adequate recharge areas. The recharge areas are continuing to be diminished today due to the rapid development of infrastructure in the region. Sapari (2015) has shown that there are certain areas in Jatinangor which is potential to be built by an artificial recharge system. This study is conducted to analyze the possibility of biofracturing artificial recharge method, which using ectomycorrhiza's Fungi to perform the symbiotic association with Pinus Merkusii in Jatinangor Education District in order to increase and maximize the infiltration rate in the remaining recharge areas.

1.1 Geological and Hidrogeological Setting

Jatinangor region is dominated by the results of the young volcano deposits like sand tuffaceous , breccias, and lavas which partly came from Mount Tangkubanperahu and partly from Mount Tampomas. However, Jatinangor is also a result of the lacustrine deposits. In the certain areas there are lava flow like on The Mount Bukit Jarian. There is an indication of a fault scarp at mount Manglayang and Mount Bukit jarian.

There are many wells drilled or dug wells at the West and South territory of Jatinangor . There are irrigation areas at the central part of the Jatinangor. There are springs in some places around Mount Bukit Jarian. In the western part Jatinangor, there are volcanic sediment areas with moderately productive aquifer with widespread deployment. There are lake deposits in some areas at the south which is medium productive aquifer. Mount Bukit Jarian is a small productive aquifer area surrounded by areas with productive aquifer.

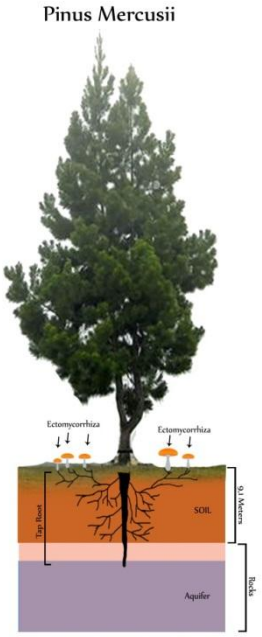


Fig 1. Artificial Recharge Model Using Mycorrhyza Symbiotic Association

1.2 Fungi

Mycorrhiza is a symbiotic assosiation between plant roots and fungi. Mycorrhiza form symbiotic relationships with plant roots like nodule bacteria in legumes. There are seven common types of Mycorrhizas known which are arbuscular mycorrhizae, ectomycorrhizae, ectendomycorrhizae, Arbutoid, Monotropod, Ericoid, and Orchid Mycorrhizae. The Mycorrhizae used in this study is Ectomycorrhizal Fungi (ECM). This fungi can do a symbiotic association with 3% of vascular plant families in the world. Fungus on ECM group are member of the Phylum Ascomycota and Basidiomycota. Hypha of Mycorrhiza will increase the capability of plant's root with it's 10 meters vertical length (Simanungkalit, 2009).

1.3 Ectomycorrhizal Symbiosis

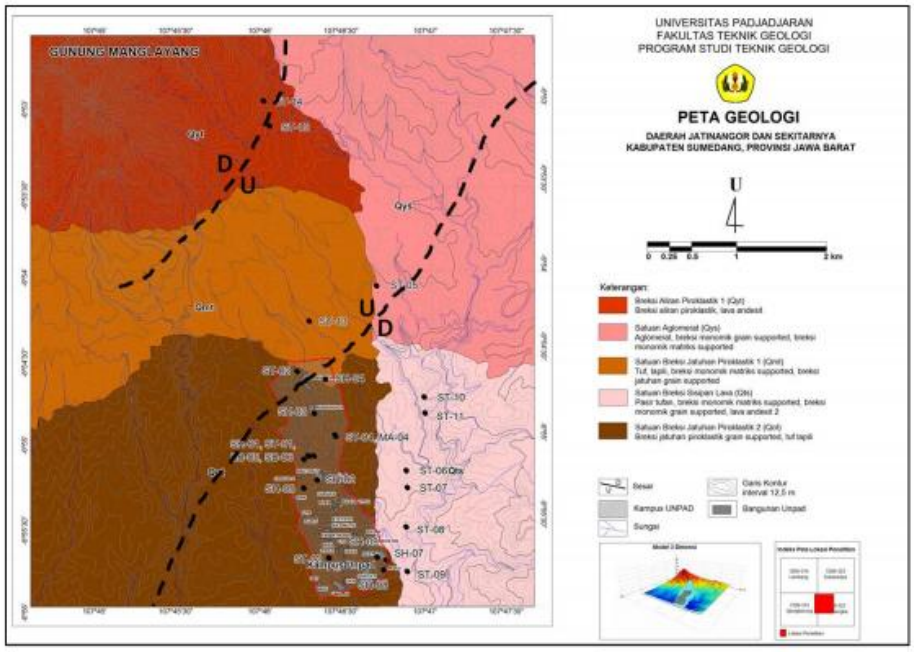
Symbiotic association of ectomycorrhizae is one of the most diverse among various other types of mycorrhizae. Diversity increased especially in terms of fungus' partner where there are about 5000-6000 species of fungi, especially from Basidiomycota, some Ascomycota, and Zygomicetes. The roots of the trees involved with ectomycorrhiza included in the group of Pinaceae, Fagaceae Cupressaceae, betulaceae, Salicaceae, Dipterocarpaeae, and Myrtaceae. This diversity supports a great diversity of symbiotic association though the group of trees mentioned looks like a little. Because, they actually cover the most dominant trees in the temperate forest. One of the tree species that can do a symbiotic association of ectomycorrhizae in Indonesia is *pinus merkusii* or Tusam Sumatra.

1.4 Vegetation

Pinus Merkusii is a typical pine species in Southeast Asia which is Spermatophyta member of the Pinaceae family. This pine grows naturally in Myanmar, Thailand, Laos, Cambodia, Vietnam, Indonesia (Sumatra) and the Philippines. However, the extensive planting also occurred in Java. *Pinus merkusii* can reach 20-40 m in high, up to 100 cm in diameter, and 2-23 m of Branch-free stem lengths. P. merkusii can grow in less fertile soil, sandy soil, and rocky soil with precipitation type of A-C at an altitude of 200-1700 meters above sea level. In natural forests there are still many pines with 70 m in high and 170 cm in diameter.

II. Methods

Preliminary study is conducted using both geological and hydrogeological field observations. Geological observations was done with rock descriptions by both megascopic and microscopic, measuring the direction of strike and dip, and measuring geological structures to produce a geological map. Hydrogeological observation was done by geometry observation of springs and wells to produce isofreatic map and the flow pattern map. The Literature study of Batara (2005) about *pinus merkusii* breeding was done to make the artificial recharge model using a symbiotic association with fungi (Mycorrhizae). The literature study was also conducted using Sapari et al (2015) and



Bandung with modification
(Hendarmawan, 2014)

Hendarmawan et al (2011) to determine the suitable location for Artificial Recharge in Jatinangor Education Area along with other primaries data.

III. Results and Discussion

3.1 Geological Analysis

Hendarmawan et al (2014) explained in their geological map that in the Jatinangor region there are at least five geological units as shown in the Fig.2. The map was made by compilation between previous research and subsurface resistivity of Jatinangor.

Rock strata containing groundwater in the study area was identified in the form of tuff, lapilli tuff and breccia matrix supported with andesite as a component. To delineate those aquifer systems is very difficult to be done in the field, especially when the drilling well data was minimal and uneven. The volcanic rock deposits are so complex so that at a very close distance eg 10 meters or 100 meters, the rocks can change both the thickness and the type. However, a search of the aquifer system can be made by combining the well log data and iso-resistivity map. Based on these datas, it can be concluded that the Free aquifer system developed in the northern and central part of Padjadjaran University campus (as delineated in the figure) based on Isoresistivity map starting with 25 till 50 meters in depth.

Both andesite and Tuff has a quite low range of permeability compared to other rock types. Andesite has a permeability range from 10^{-21} up to 10^{-19} m/s, while tuff has a permeability range from 10^{-20} to 10^{-17}. This value is considered very small when compared with sandstones which are common in lowland with permeability ranges from 10^{-19} up to 10^{-13} m / s.

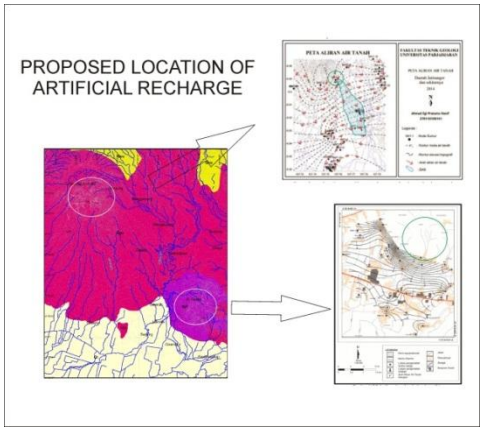


Fig 3. Proposed Location to make Artificial Recharge

3.2 Hidrogeological Analysis

Based on the hidrogeologic flow pattern map of Sapari et al (2015) which is located in Mount Manglayang, it can be seen that the groundwater flow tends to lead from the north to the south leading to the education area Jatinangor. Based on The flow pattern map that has been made at Mount Bukit Jarian located in the southeast area of research, the groundwater flow pattern also leads to the south and partially directed to the southwest which is also the Jatinangor education area. Roughly, both in Mount Bukit Jarian and Mount Manglayang has a flow direction that lead to the Jatinangor education Area in almost all existing Watersheds as can be seen in the picture (fig.3).

According to Finda and Idris (2010), permeability in Jatinangor Area is considered low which is 4.32 L/m^2/day or around 0.0003 cm/minute. This condition leads to low infiltration rate and wet soil . Egi et all (2014) has calculated that Jatinangor has infiltration rate by 96,286,0800 m^3/year while the rate of extraction of it is about 10% which exceed the national standard which is 6%. Sapari et all (2015) has suggested feasible areas to build a vegetation artificial recharge to improve this situation.

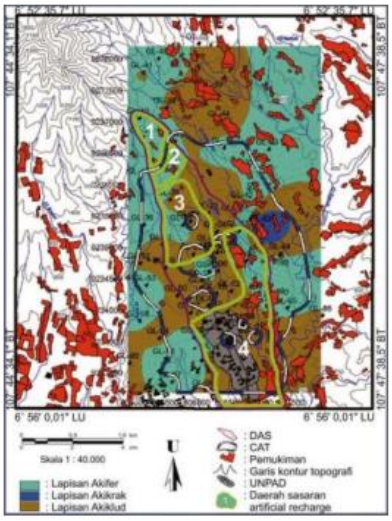


Fig 4. Proposed location at Mount Manglayang to build Artificial Recharge (Sapari et al, 2015)

The map above is right at the foot of the mount Manglayang. Sapari et al proposed that area 1 is a suitable area for planting Artificial recharge in the form of vegetation. The plants are still rarely found in the area, so it can be used for planting pinse on this vacant land.

Meanwhile, the Authors also propose the foot of the Mount Bukit Jarian to be built an Artificial Recharge (fig.5) considering that the place also has many vacant lands like the foot of the Mount Manglayang as proposed earlier.

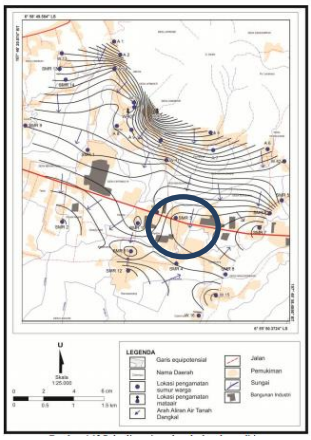


Fig 5. Flow Pattern Map and Proposed location around Mount Bukit Jarian to build Artificial Recharge

3.3 Mechanism of Artificial Recharge

Basically, The recharge areas in the region are narrow and have a low permeability . Therefore, the addition of water entry point becomes important. As can be seen in Figure 1, ectomycorrhizal fungus grown around the *Pinus Merkusii* with the distance of about 20 cm from the main tree.

Ectomycorrhizal fungi form a symbiotic relationship with a plant by forming a sheath around its root tip. The fungus then penetrates the root along the middle lamellae between cell walls by inward growth of hyphae, thereby form a Hartig net, a complex network of fungal hyphae that is the site of nutrient exchange between the fungus and the host plant. The fungi and the plant essentially fuse walls, and nutrient exchange appears to take place across these walls. The fungus gains carbon and other essential organic substances from the tree and in return helps the trees take up water, mineral salts and metabolites with increased surface area of hyphae emanating through the soil. Ectomycorrhizal fungi also protect host trees from attack by parasites, predators, nematodes and other soil pathogens. Thus, most forest trees are highly dependent on their fungal partners and could possibly not exist without them in areas of poor soil quality.

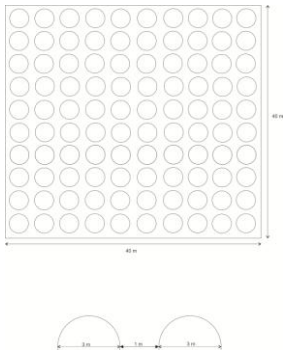


Fig 6. Formation arangement of Artificial Recharge

According to Aubertin (1971), The physical entrance and expansion of a root in the soil compresses the soil adjacent to it and locally changes the soil's porosity and bulk density. This is accompanied by a shift of pore-size distribution toward the smaller capillary-size pores called macropores. In addition, a higher percentage of clay and mineral grains oriented tangent to the roots' surface is to be found adjacent to the root-soil interface than in the soil mass. These macropores, along with the residues remaining from organic decomposition, promote a relatively stable conduit for the rapid conductance of free water, air movement, and new root growth which means increase the infiltration rates up to several hundreds times higher than ordinary soil. The above process mechanisms therefore are considered as Biofracturing.

The Fig. 6 illustrates the arrangement proposed in planting artificial recharge. Each pine is planted with a distance of 4 meters between the main body of the plant. Assuming that the plant roots will spread as wide as the diameter of their canopy which is estimated to a maximum of 3 meters, the area of 40x40 m^2 can be planted up to 100 *Pinus merkusii* including fungus plastered around it.

Assuming that by planting trees on a vacant land could increase the infiltration rate until up to 100 times faster, our model which is the artificial recharge area of 1600 m^2 will increase the infiltration rate to 688,000 liters per day in minimum or about 247,680 m^3/year. This is absolutely a huge value considering that it only use a relatively small area.

IV. Conclusion

It can be concluded that there are two main suitable areas to be built by an Artificial Recharge, which is at the southern foot of the mount Manglayang and the southwestern foot of the mount Bukit Jarian . It is estimated that the construction of artificial recharge in these areas will increase the quantity of infiltration in the region, which can affect the ground water quantity in the aquifer of Jatinangor Eductaion area to prevent the water shortage in the future.

However, There is the need to do a further research about whether the foot of the mount Bukit Jarian is suitable for planting the artificial recharge caused by the lack of datas.

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Community-Based Ecotourism: Basis for Sustainable Development in Sibuyan Island, Romblon

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Abstract

Tourism is seen for having a huge impact on rural communities. It is generally known for its pro-poor implications that convey socio-cultural, political, ecological, and economic benefits to steer a community if directed with strong policies. Community-based ecotourism in particular has a great prospective in uplifting the said different factors of a locality. Sustainable development, on the other hand, plays side by side with ecotourism as they both meet the standards of a pro-poor, pro-environment, and pro-economic thrust on mitigating the environmental degradation and poverty.

The researcher determined the perceptions of a key sector on ecotourism as basis for sustainable development, investigated the positive and negative impacts of ecotourism in the rural communities, and explored the effect of ecotourism development in the standard of living of the local people in the island known as the "Galapagos of Asia."

Sibuyan is composed of three municipalities: San Fernando, Cajidiocan, and Magdiwang. Using the Slovin's formula, the respondents were divided per municipality; One hundred sixty (160), one hundred forty three (143), and ninety four (94) respectively. Using percentage distribution and weighted mean as statistical treatments, results showed that ecotourism gives more positive outcomes over negative outcomes. Aside from the survey method, the researcher interviewed resource persons from the local government units and non-government organizations, analyzed pertinent data from different agencies of government, and observed the implications of ecotourism development in Sibuyan Island.

Keywords: community, ecotourism, environment, sustainable development

1. INTRODUCTION

Tourism has been widely regarded as the fastest growing industry in the world and caters to almost all countries with distinct characteristics and ethos that promotes friendship in diversity and creates transnational harmony. Tourism is also regarded as a tool or mechanism from which countries, states, cities, provinces, and local communities derive their economic wealth.

Tourism also means globalization. There are five things that constitute migration (Kearney, 1995 cited in Oracion, 2007) through global and transnational space: the movement of people, information, symbols, capital and commodities. Tourism can be viewed as participating in globalization because it creates these forms of movement. Thus, globalization makes tourism a subject for certain issues and concerns among local communities which are the primary stakeholder of tourism development due to the exploitation of the environment and unsustainable visit of some tourists. Climate change, deforestation, and other environmental issues still hinder the full-blown sustainable progress. These phenomena have impelled the UNCED or the United Nations Commission on Environment and Development in 1987 to recommend to governments to promote a more sustainable form of development. In 1992, this event gave way to the Earth Summit in Brazil. The United Nations conference was a record in terms of both its size and its scope of agenda and concerns. Two decades after the first global environment conference, the UN's drive was to help governments on rethinking economic development and finding ways to halt the pollution of the planet and destruction of its natural resources. Hundreds of thousands of people from all walks of life were drawn into the Rio process. They persuaded their leaders to go to Rio and join other nations in making the difficult decisions needed to ensure a healthy planet for generations to come (United Nations, 1992). Building on the report of the Brundtland Commission, the UN summit focused on three broad concepts: 1) An "Earth Charter" covering a number of principles aiming at development and the protection of the environment, was the first focus for discussion. 2) "Agenda 21" was intended to be a global action plan for sustainable development; 3)developing countries demanded a substantial increase in new funding from developed countries to contribute to sustainable development in the South. Negotiations attempted to reach agreements at least on the broad outlines of several conventions covering climate change, biological diversity and forests among others, especially with representatives from developing countries emphasizing at Rio the importance of their right to economic development, which goes together with growing impacts on the environment, so that industrialized countries have a special responsibility for the realization of the global environmental goals stated at UNCED (World Summit, 2002).

Tourism Development Impacts in the Philippines

The Philippines was one of the first countries that swiftly responded to the calls made at the Earth Summit. Three months after, the government established the Philippine Council for Sustainable Development (PCSD) to manage the execution of the country's Agenda 21 oaths and formulate policies and programs that are supportive of sustainable development (Philippine Council for Sustainable Development, 2012).

According to Chang, "Sustainable tourism is about sustainable development, and it follows the definition of SD as 'meeting the needs of the present generation without compromising the ability of future generations to meet their own needs'. The concept of sustainable tourism underlines the importance of achieving a balance between three dimensions, in order to guarantee its long-term sustainability: *economic, socio-cultural, and environmental"* (Chang, 2011).

The concept of sustainable tourism development has become the main focus of growing attention among tourism theorists and practitioners over the last decade. Tourism is perceived as a useful tool for sustainable development and has become more and more popular within development politics. It has now achieved extensive acceptance as a desirable objective of tourism development policy and practice and many organizations representing destinations or tourism industry sectors have put out sustainable tourism development plans and sets of principles (de Boer, 2012).

Tourism represents a huge market in the global sphere. In 2002, the number of global tourist arrivals went up to as much as 702.6 million and is projected to reach over 1.56 billion by 2020. This represents about US$ 474.2 billion in receipts at an international scale (UNWTO, 2002). However, ecotourism represents a very small part of this market. "Ecotourism represents a small segment of nature-tourism. Nature-tourism is understood as travel to relatively undisturbed or uncontaminated natural areas and constitutes about 15% of all tourism (World Wildlife Fund, 1995). Significantly, it contributes to the country's healthy economic thrust.

In 2013, according to the Department of Tourism, the Philippines remain to be a safe and fun destination for all tourists whether of local or foreign origin. The country's central part, despite the typhoon Haiyan's devastation in the same year, plays host to several top destinations such as Boracay, Cebu, Bohol, Iloilo, and Bacolod, which remain open for business with their respective ports of entry still accessible to tourists. Having one of the world's longest coastlines, the Philippines offer an array of limitless attractions found all over more than 7,107 islands of rich and natural beauty.

Biodiversity and the Emergence of Ecotourism in the Philippines

In 1991, the Department of Tourism in collaboration with the United Nations Development Programme (UNDP) prepared the Philippine Tourism Master Plan (TMP). Among the tourism objectives established by the TMP are one aimed at positioning the country as a world-class tourism destination under the guiding principle of sustainable tourism development (National Ecotourism Strategy, 2001).

In 1992, a National Tourism Congress took up this theme and at the concept of "ecotourism" was introduced into the Philippines. Then, between 1994 and 1998, a series of regional ecotourism seminars discussed the concept. This work culminated in 1998 in a Technical Workshop on Sustainable Tourism, during which the elements of a sustainable development framework were identified and key issues defined (National Ecotourism Strategy, 2001).

On June 17, 1999, Executive Order 111 was issued. This established a formal organizational structure for the development of ecotourism in the Philippines. EO 111 created a National Ecotourism Development Council (NEDC), with the composition of the Secretaries of Tourism, Environment and Natural Resources, Interior and Local Government, Trade and Industry, Finance, Education, Culture and Sports, and the Director-General of the National Economic and Development Authority and representatives from the private sector and non-governmental groups. Underneath the NEDC, a National Ecotourism Steering Committee (NESC) and 15 Regional Ecotourism Committees (RECs) were established to implement the programs and activities approved by the Council. EO 111 also called for an Ecotourism Technical Working Group (ETWG) to provide technical and administrative support to the NEDC and the NESC. All

of these bodies now exist and are active. They are referred to collectively in the Preliminary Draft NES as "the EO 111 bodies" (National Ecotourism Strategy, 2001).

The first function assigned to the NESC in EO 111, and the one that provides the essential rationale for the NES planning work currently under way, is:
'Formulate and develop a national ecotourism strategy and program for the promotion and development of ecotourism in the country.'

EO 111 further stipulates that:
The National Ecotourism Strategy shall be prepared by the Council to provide an integrated management plan, which shall warrant a comprehensive direction for the future of ecotourism in the country by recognizing issues and problems for its sustainable development and recommend feasible approaches in addressing these issues. The Strategy shall be formulated in consultation with concerned stakeholders in the environment and tourism sectors including indigenous peoples and local communities to be effected by ecotourism development.

And further:
To complement and support the aforementioned Strategy, a National Ecotourism Program shall be developed. The program shall encompass the major aspects of ecotourism, which are 1) development, management and protection of identified ecotourism sites; 2) product enhancement and development; 3) environmental education and information campaign; 4) support programs for community stewardship and livelihood development (National Ecotourism Strategy, 2001).

Various articles published internationally labeled the Philippines as one of only 18 mega-diverse countries in the world and ranks 25th worldwide in the total number of animal and plant species. The country offers its unique environment that the world admires. Home to some of the world's most endangered flora and fauna, incomparable, friendly people and diverse culture, the Philippines is surely a destination for everyone that wishes to fulfill their travel vice. The country offers almost all types of reasons why the world should see it, whether it is for business and investment, a conference or company group meeting, for vacation and a lot of other reasons (personal, marriage, health, shopping, etc.).

There is a shared reason why tourists, both locals and foreigners alike, visit the Philippines. From the reality of the continuous degradation of the environment, the clamor of the Filipinos has been always present to mitigate the depletion of the environment by promoting a more sustainable form of tourism development. Hence, this paved way to the creation of the term "Ecotourism". The term was a sensation more than a decade ago and its definitions are still changing. In 1996, known and considered as one of the first persons who coined the term was Hector Ceballos-Lascurain. He defined Ecotourism as:

"Tourism that consists in travelling to relatively undisturbed or uncontaminated natural areas with specific objective of studying, admiring, and enjoying the scenery and its wild plants and animals, as well as any existing cultural manifestation (both past and present) found in the areas. In these terms, nature-oriented tourism implies a scientific, aesthetic, or philosophical approach to travel, although the ecological tourist need not be a scientist, artist, or a philosopher. It emphasizes that the person who practices ecotourism has the opportunity of immersing himself/herself in nature in a manner generally not available in the urban environment" (Madeja, 1999).

Ecotourism has become a significant economic movement or activity in natural areas everywhere in the world which is expected to contribute to both conservation and development. According to Oketch, "It brings out opportunities for visitors to experience powerful manifestations of nature and culture and to study about the importance of biodiversity conservation and local cultures" (Okech, 2011).

Overview of Biodiversity in Sibuyan, Romblon

Located at 12 degrees 21'N latitude and 122 degrees 39'E longitude in the center of the Philippine Archipelago about 350 km south of Manila, Sibuyan is the second largest island of Romblon Province. It has a land area of roughly 45,600 hectares, more than half of which is covered with forest. At its widest points, the island measures about 24 km North to South and 28 km East to West (Anon, 1989). As of September 1995, its population stood at 47,482 distributed mainly along the coastal plains and on the lower slopes of the island's mountainous forests. The majority of this population depends on subsistence level agriculture and fishing (Tongson, 2014).

At the heart of Sibuyan Island is the Mt.Guiting-Guiting Natural Park (MGGNP). Conservation efforts for this strikingly beautiful mountain are of particular importance because it is the only remaining mountain in the Philippines with relatively intact habitats along its entire slope. These habitats include: summit heath land and grasslands, mossy forests, mountain forests, lowland evergreen forests, and forests over ultra-basic rocks. Mt. Guiting-Guiting's biodiversity is also one of the richest in the Western Visayas biogeographic region. Fifty-four species of plants and five species of mammals are endemic to the island. In addition, 10 species of fruit bats and 131 bird species, 24 of which are migrants, have been recorded on the island. In terms of forest density, a study by the National Museum revealed an astonishing 1,551 tree individuals (at 10 cm diameter at breast height) per hectare. Teak wood, considered the hardest wood, is still found in significant numbers (Tongson, 2014).

Despite its steep slopes and relative inaccessibility, Mt.Guiting-Guiting's abundant resources have not been spared from the destructive means by which the local people meet their economic needs. Logging has been documented to occur on the island dating back to Spanish colonial times. Timber extraction from the 1970s to the early 1990s was even more fast-paced to meet the huge demand of the mining pits in Masbate. At the same time, furniture-making was fast becoming a backyard industry around much of the island. Blast fishing and cyanide poisoning brought in sizable catch but destroyed large tracts of coral reef. Upland dwellers engaged in swidden farming and poisoning of rivers to catch eels and shrimps. Substantial tracts of mangroves were cleared for household fuel and conversion into fishponds (Tongson, 2014).

Concern about the environmental threats of the unregulated and unsustainable use of the island's forest resources prodded the three municipalities of Sibuyan – Magdiwang, Cajidiocan, and San Fernando - to promote the conservation of Mt. Guiting-Guiting and other significant natural treasures of the island.

Community-based Ecotourism in Sibuyan, Romblon

The term "community-based ecotourism" is used to describe ecotourism ventures that are characterized by high environmental consideration, increased control and involvement of the local residents, as well as significant benefits for the host community (World Wildlife Fund, 2001).

Sibuyan Island has collaboration with renowned NGOs to promote community driven Ecotourism which links the different Ecotourism sites in the island. The map below illustrates the chain of activities visitors can enjoy.

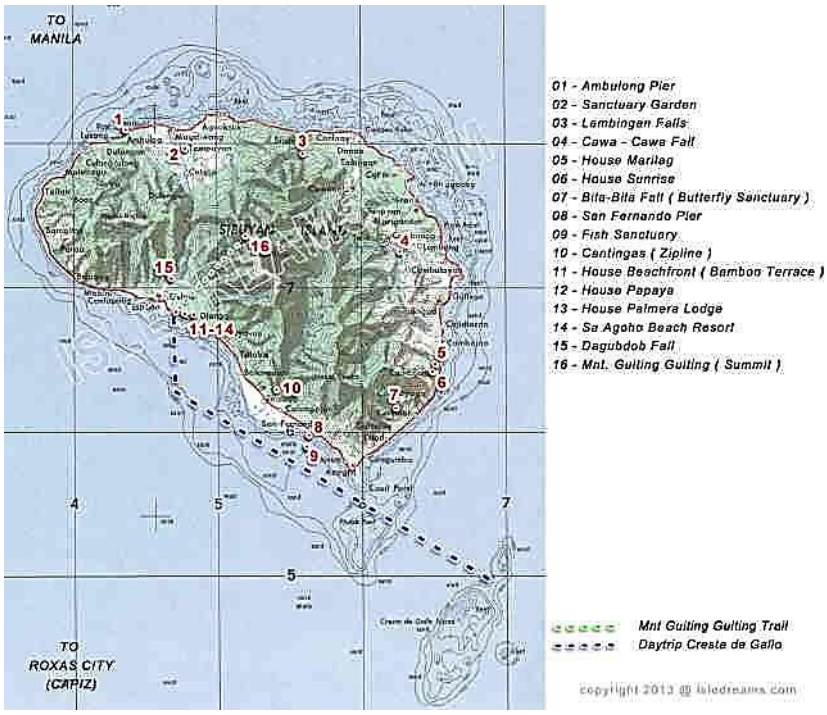


Figure 1.1
Sibuyan Tourism Activity Map

Among the highlights of the island are the Mt. Guiting-Guiting Natural Park and Cantingas Eco-Adventure Zone which offer different Ecotourism activities arranged by the community in partnership with the Local Government Units.

Mount Guiting-Guiting Natural Park (equivalent to the International Union for Conservation of Nature or IUCN category of National Park) in Brgy.Tampayan, Magdiwang was established to protect these forests, which are mainly in the center and north of the island, and covers an area of 157 square kilometers (61 sq mi) out of Sibuyan's total area of 445 square kilometers (172 sq mi).

On February 1996, Mt.Guiting-Guiting was proclaimed a Protected Area under the National Integrated Protected Areas System (NIPAS) through a Presidential Proclamation. With a total land area of 15,475 hectares and an approximately 10,000 hectares as an additional buffer zone, the park straddles the three municipalities of the island (Tongson, 2014).

The Cantingas River also known as Cantingas Eco-Adventure Zone in Brgy. Taclobo, San Fernando is surrounded by rich green rice fields and by a rocky landscape. Declared as the Philippines' cleanest and world's second cleanest river, it bestrides different parts in the island and generates 900 kilowatts of hydroelectric power that provides electricity to more than 50,000 local inhabitants. The River is recognized and protected by different foundations and conservationist groups.

The table below shows the complete list of ecotourism attractions per municipality.

MUNICIPALITY	ECOTOURISM DESTINATION

Magdiwang	1. Mt. Guiting-Guiting Natural Park
	2. Marine Garden
	3. Lambingan Falls
	4. Dalipi River
	5. Gaong River
	6. Ferrol Fish Sanctuary
San Fernando	7. Cantingas Eco-Adventure Zone
	8. Cresta de Gallo
	9. Busay Falls
	10. Lagting Falls
	11. Lamao Lake
	12. Dagubdob Falls
	13. Bilala Falls
Cajidiocan	14. Cawa-Cawa Falls
	15. Little Baguio
	16. Sugod Fish Sanctuary

Table 1.1
Sibuyan Ecotourism Sites

The community driven programs of Sibuyan Island were developed hand in hand by the local governments, non-government organization, and local communities for the appreciation and preservation of their island's unmatched beauty.

While objective criteria can be established to measure the economic and environmental effects of an activity in quantifiable terms, measuring social, cultural and psychological impacts defined by the perceptions of stakeholder groups, such as the local population, administrators or a combination of these, are typically subjective and not easily quantified. As sustenance for additional tourism development is, however, correlated to its perceived positive and negative impacts, identifying the perceptions and attitudes of various stakeholders en route for tourism development in a community should be taken as a first step in tourism planning in order to ensure trust, cooperation, harmony and mutual benefit for all those involved. Many researchers have, therefore, focused on the attitudes of the residents in the host community related to various kinds of tourism impacts (Akan & Kuvan, 2012).

The impacts of ecotourism on the local people who are the core of development are mysterious proposition in alleviating the communities from poverty. By using means of alternative income delivery capabilities, local communities are the main subject and beneficiaries of truth about the findings of this research.

The researcher is a native of a pristine and peaceful environment in the island province of Romblon. His experiences in his native land encouraged him to study the community-based ecotourism potentials and to measure its sustainability by means of generally-accepted parameters. His reflections about the realities of environmental degradation, mining, and climate change motivated him to pursue the study. Enlightened by the realities of the rich biodiversity in the Philippines, the researcher is also inquisitive about the realisms of poverty alleviation in local communities through Ecotourism.

In the ice-age island of Sibuyan, dubbed by some local and international natural scientists as the "Galapagos of Asia", the probe attempted to enlighten the public about the truth on the stakeholders' understanding on the true value of community-based ecotourism. The researcher investigated the perceptions of the Local Government Units as an administering body, Non-Government Organizations and Local Communities as legatees respectively.

Their perceptions and understanding about the community-based ecotourism as basis for sustainable development anticipates the delivery knowledge and awareness for the benefit of other researchers, local government units, rural communities and environmentalists in the Philippines.

Statement of the Problem

The study sought answer as to how Community-Based Ecotourism affect the parameters of sustainable development: Economic, Ecological, and Socio-cultural aspects of the municipalities of Cajidiocan, Magdiwang, and San Fernando. Specifically, answers to the following research questions were sought by the researcher:

1. What are the *Positive and Negative Economic, Ecological, and Socio-cultural Outcomes of Ecotourism in Communities* of:
1.1 Cajidiocan
1.2 Magdiwang
1.3 San Fernando

Objectives of the Study

1. The study wants to identify the benefits and disadvantages of Community-Based Ecotourism based on the perceptions of the rural community.
2. The study wants to determine the effectiveness of ecotourism as an alternative livelihood and a sustainable tool of development.

Significance of the Study

Theoretical Significance

According to King (2010), "the ecotourism theory suggests that economic development and natural resources conservation are compatible goals" (King, 2010 cited in Chiutsi et.al, 2011). Thus, new meanings of ecotourism have focused on conservation management, education, ethics, sustainability, impacts and local benefits as the main variables. Weaver (2008) further emphasized that "Ecotourism is a form of tourism that raises educational experiences and appreciation of the natural environment, or some components thereof, within its associated cultural context." It is therefore restated that ecotourism is administered according to the best practice of the industry to attain ecologically and socio-culturally sustainable results as well economic feasibility (Weaver, 2008 cited in Chiutsi et.al, 2011).

Practical Significance

Ecotourism is still a developing activity in the Philippines. Since it is a nature-based activity, ecotourism has a huge potential as the country capitalizes on its natural resources and rich biodiversity. Many of the provinces or rural areas aren't cognizant of the magnitude of advantage

they might gain once it is administered in the realms of sustainability. This research attempted to revive the interest of the locals to be sensible about the importance of their natural wealth. It has been two decades since the last research study was conducted in the island in light with ecotourism. It was the Evelio B. Javier Foundation Inc. that conducted a study twenty years ago and the United Nations Development Programme (UNDP) in 2002 which started a program for ecotourism development for Sibuyan Island. Its main focus is about biodiversity conservation and institutionalization of ecotourism programs and projects as well as setting up an island-wide network that will serve as support mechanism for environmental conservation and management. According to UNDP, "the project intends to assist local stakeholders develop and institutionalize Sibuyan ecotourism programs and activities that will support and complement the existing tourism and visitor management strategies of National Integrated Protected Areas Programme (NIPAP) aimed at preserving and protecting biodiversity of the Island, particularly the Mt. Guiting-Guiting. It will initiate and undertake activities that will help develop and enhance ecotourism program management, linkaging and networking capabilities of the local stakeholders. It will assist the NGOs and POs of the three municipalities in developing and implementing ecotourism activities that will provide income generating opportunities" (United Nations Development Programme, 2012).

This study gave an overview and update on the present existence of ecotourism in the Philippines that is existent in Sibuyan Island. It is hoped to revitalize and supplement the economic activities in the province of Romblon and present knowledge on the benefits and contribution of ecotourism to the local communities in the country.

The measure of awareness for the environment vis-a-vis development has helped to amend or formulate policies for the environmental conservation and people empowerment. The policies for the environmental conservation are not meant to restrict development patterns in the modern times but rather created a more sustainable form and give importance to the long-term benefit for the participating communities. This study helped the local governments and policymakers to plan and implement ordinances with respect to the National Ecotourism Strategy and sustainable development. Furthermore, this study also directed the local government in using sustainable tourism development activities with firm implementation and with respect to economic, ecological, and socio-cultural necessities.

The study also empowered the local people to continue and improve by appreciating their contributions to the local economy and by giving their services for the promotion and conservation of their natural treasures. This is also an opportunity for the locals to diversify their capacities and know-how by attending trainings and seminars to suit the needs of the visitors and at the same time adding income to their main source of livelihood.

This study also opened the minds of the young tourism graduates and professionals that aside from the airline, hotel, restaurant, and travel industry, the public bureaucracy is there open for them to instill new ideas and insights for the improvement and revitalization of the Philippine tourism bureaucracy. This study also encouraged fresh thinkers to be part of the new paradigm shift in overhauling the old culture our government has known for quite long time, eliminating the conditional services and motives for self-benefit and ultimately reviving the long lost tradition of honesty, uprightness and excellence in public service by instilling upright, innovative, proactive and technocratic individuals to perform the job.

Ecotourism has an opportunity to be a model of sustainable development especially in the areas with rich natural resources. Mining, as a form of livelihood to some of the locals who are

employed by small and large scale mining corporations and are cognizant about the environmental degradation and short-term economic benefit to the local communities, have been opposed by the people and have been a favorite subject for debate among local and national officials and politicians. This study opened the eyes of the civil society that more than mining, by means of practicing sustainability, the people become aware of the importance of their ecosystem by promoting ecotourism as a non-invasive and non-extractive form of development with less environmental cost.

The researcher proposed in this study that ecotourism is also a tool for socio-cultural empowerment and ecological appreciation that uplifted the social esteem of the people as they are the core beneficiaries of development. Honoring and respecting their environs at the same time brought social cohesion and cultural solidification.

Theoretical Framework

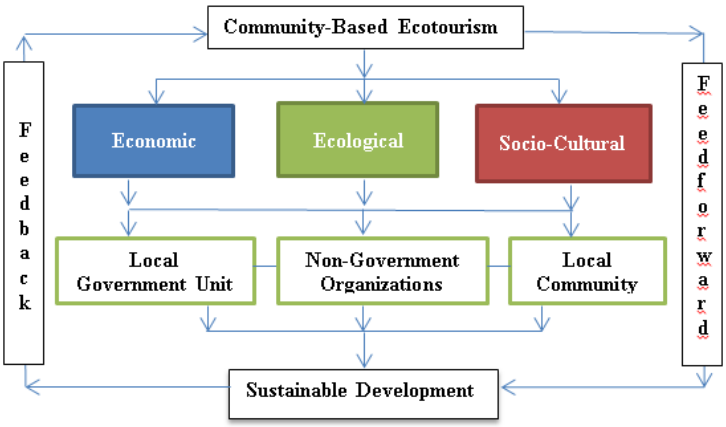
The researcher sought the point of view of the LGUs, NGO and the local communities in selected rural communities in Sibuyan Island about the presence of ecotourism project based in their communities. The theory of social exchange was used as the theoretical framework.

According to Nunkoo and Ramkissoon, Social Exchange Theory (SET) was defined as "a general sociological theory concerned with understanding the exchange of resources between individuals and group in an interaction situation" (Nunkoo & Ramkissoon, 2011). SET has a social psychological and sociological perspective that defines social change and stability as a progression of negotiated exchanges between people in society. Thus, varied perceptions from different residents can provide insights into the nature and degree of tourism impacts towards the perspective of tourist destination (Nunkoo & Ramkissoon, 2011).

The Social Exchange Theory (SET) has been adapted widely by tourism researchers since the 1990s and has roots in economics, psychology and sociology. For Social Exchange Theorists, when the cost and benefits are equal in a relationship, then that relationship is defined equitable.

The basic assumption of exchange theory is that individuals establish and continue social relations on the basis of their expectations that such relations will be mutually advantageous. Moreover, SET implies that residents' support is grounded on their assessment of the benefits and costs from the industry (Nunkoo & Ramkissoon, 2011). This theory of Social Exchange was derived from the research study of Murla in 2011.

Conceptual Framework



Community-based ecotourism (CBE) is used to describe ecotourism ventures that are characterized by high environmental consideration, increased control and involvement of the local residents, as well as significant benefits for the host community (World Wildlife Fund, 2001). This concept is clearly distinguished from other ecotourism ventures that are largely or even totally planned and managed by outside operators and generate negligible benefits for local people (Manu & Kuuder, 2012)

The sustainable development parameters are mainly classified as *Ecological, Economic, and Socio-cultural.* The preceding components are set to gauge the efficacy of community-based ecotourism in the municipalities of Magdiwang, San Fernando, and Cajidiocan. The development of a community is believed once the parameters or components succeeded and confidently accepted by the stakeholders.

Under the economic development, the research adopted the approaches used by Murla (2011) by searching the benefits to the community through the following: regular or part-time employment for the residents, employment of daily workers (e.g. carpentry, plumber, painter, electrician, welder, et cetera), employees receiving better wages, increasing family income, creation of small and medium enterprises (fruit stands, sari-sari store, souvenir shops, local goods), establishment of hotels, establishment of restaurants, establishment of recreational facilities, increase in the variety of handicrafts and souvenirs, increase of government income and internal revenue allotment, improvement of roads, and improvement of water supply. While the negative or disadvantages are: traffic congestion, increase in the cost of living, increase in the price of land, increase in cost of house rental, and increase in the price of local commodities (Murla, 2011).

Under the ecological development indicators in this study are the ecological outcomes in terms of programs realized by ecotourism activities. The negative environmental outcomes measured are: increase in air pollution, increase of noise, dirty surroundings, and destruction of natural environment (Murla, 2011).

For socio-cultural indicators, the research examined on the following items: employment of livelihood for women, working opportunity for students as part-time workers, shift of jobs from fishing and agriculture to tourism, increase and improvement of educational facilities, improvement of health services and the effect on local customs and culture. The negative social outcomes are overcrowding due to increase in settlement of people, increase in crime rate and cultural shock brought by foreign tourists (Murla, 2011).

The sustainable development parameters are measured through qualitative and quantitative approach. The methods were used in the form of interviews among provincial government employees, municipal employees, researcher's personal observation and survey for the household residents.

The local community perceived the Community-based Ecotourism. The positive implication of ecotourism activities means it benefited them; while provided the community develops negative outcome, it means that Ecotourism is not beneficial to them. Provided that Community-based Ecotourism become successful through the perceived benefits, the LGUs and the local community will likely be willing to become proactive in planning, implementing, funding, empowering and participating community, a clear indication of a sound and viable economy. However, if it conveys more drawbacks, it will attest that ecotourism cannot become a tool for sustainable development in a community.

Scope and Limitation

The rural communities covered in this study are the municipalities of Magdiwang, Cajodiocan, and San Fernando. The sites are based on the researcher's accessibility, resources, and the recommendations of local acquaintances.

The study has focused on the perception of ecotourism stakeholders in the municipalities namely local government units headed by the local officials, non-government organizations and household residents. The local government units are the municipal officials supervising the ecotourism areas and the household residents who stay inside the municipality owning or renting a house.

The study has acquired data limited in the list of research questions stated in the previous part of this paper. Each sustainable development parameter is based on local articles and supported with international journals used as reference. The data reflected are purely based on opinions, perceptions, archival documents, and collected empirical data.

The information gathered is as of February 2015, so any developments after this date are not included in this study.

2. RESEARCH METHODOLOGY

This Chapter discusses the research design and methodology used by the researcher in the study. It includes details of each research design including the methods, tools, sample size, participants, and sources which become valuable in answering research problems.

The data gathering worked on literature research of some books, international journals, news articles and web references. Field research was done to gather data by conducting an interview with key persons such as officials of DOT and DENR; municipal officials; direct personal observation in Magdiwang, Cajidiocan, and San Fernando; and survey questions for the local residents.

The study seeks the participation, benefits and disadvantages of Ecotourism Stakeholders in Sibuyan Island in the province of Romblon.

Research Design and Sources of Data

Descriptive research was used to answer the questions like who, what, where, when and how much, and how many (Suzuki, 2007). Through different methods of qualitative research, the researcher was able to acquire the facts necessary in the study.

Qualitative type of research was utilized to collect both basic and complex information necessary in the study. The bases of qualitative data are interviews, physical data, participant observation, and electronic data (Suzuki, 2007). The research has collected data about Sibuyan Island and its three municipalities namely Cajidiocan, Magdiwang, and San Fernando and its corresponding ecotourism attractions.

Quantitative type of research through survey instrument was utilized to collect information on perception of the residents in terms of the presence of the Ecotourism project inside the community.

Survey Research

A survey questionnaire was used to obtain the insights of a general group such as barangay households. The survey will identify the profile of a household member. The researcher will be able to get the insights of a respondent in terms of the presence of the Ecotourism project inside their community and in terms of satisfaction and disappointments.

Respondents and Selection process

The survey research was conducted among the locals inside the municipality. The researcher initially used the Slovin's formula to distinguish the number of respondents that will answer the survey questionnaires. Through the confidence level of 95 percent (giving a margin error of 0.05), the researcher identified the number of population as participants for the survey. In the Municipality of San Fernando, the National Statistical Coordination Board identified 13,500 registered voters based on year 2010 record. Using the Slovin's Formula, the identified participants are 160. The researcher distributed 200 survey questionnaires in randomly selected houses and local institutions. Preferably, the voting population was assigned to answer the survey form. In the Municipality of Cajidiocan, the National Statistical Coordination Board identified 12,109 as the number of registered voters based on year 2010. Using the Slovin's Formula, the identified participants are 143. The researcher distributed 160 survey questionnaires in randomly selected houses. In the Municipality of Magdiwang, the National Statistical Coordination Board identified 7,934 registered voters based on year 2010 record. Using the Slovin's Formula, the identified participants are 94. The researcher distributed 120 survey questionnaires in randomly selected houses and local institutions.

$$\begin{aligned} &13,500 \\ &+\ 12,109 \\ &\quad 7,934 \\ N &= 33,543 \end{aligned}$$

$$n = \frac{33,543}{1 + 33,543(.05)^2}$$

$$= 395$$

$$\% = \frac{395}{33,543}$$

$$= .01177 = 1.18\%$$

San Fernando

13,500 x .0118 = 160

Cajidiocan

12,109 x .0118 = 143

Magdiwang

7,934 x .0118 = 94

In the Municipality of San Fernando, the researcher distributes a total of 200 survey questionnaires. The distribution started in the Romblon State University – San Fernando Campus, Poblacion, Terminals, and other business establishments where the locals can be easily found. The distribution was done at random. The 200 distributed questionnaires was successfully and completely retrieved and used for data analysis.

In the Municipality of Cajidiocan, the researcher distributes a total of 160 survey questionnaires. The distribution started in the Romblon State University – Cajidiocan Campus, some local

institutions like the Parish Church, Terminals, and other business establishments where the locals can be easily found. The distribution was done at random. The 160 distributed questionnaires was successfully and completely retrieved and used for data analysis.

In the Municipality of Magdiwang, the researcher distributes a total of 120 survey questionnaires. The distribution started in the Magdiwang Public Market, Magdiwang Central Elementary School, Magdiwang National High School, Terminals, Rural Health Unit, Philippine National Police Station and other business establishments where the locals can be easily found. The distribution was done at random. The 120 distributed questionnaires was successfully and completely retrieved and used for data analysis.

Instruments

The household survey questionnaire was adopted from the study of Murla (2011) entitled "Understanding Agri-tourism in Two Rural Areas of Cavite" and is divided into two parts. The items in the survey are also translated in Filipino for easy understanding. The survey questionnaire has been contextualized to fit in the needs of the present investigation. The author used "Tourism" as the main subject for each question which is perfect for the present study. The first part of the survey was the Respondent's profile where questions are asked such as: age, gender, civil status, occupation, and place of occupation where results will be discussed in Chapter 4. The second part of the survey questionnaire is about the resident's point of view on Ecotourism inside their community. The respondent's insight was divided into three parts: the first part is about the point of view on Ecotourism inside the Municipality, the second part is about the contribution of Ecotourism in the municipality through the sustainable development parameters: economic, ecological, and socio-cultural. The third part is about the negative impact of Ecotourism inside the Municipality. A four-point Likert scale will be used to identify the degree of evaluation (1-strongly disagree, 2-disagree, 3-agree 4-strongly agree). Most of the items on the evaluation portion were taken from journals related to community tourism, rural tourism, community's perception on tourism, and advantages and disadvantages of tourism.

The survey question had undergone pre-testing to identify the lacking questions which can also become significant to achieve the research objectives. A pre-test of the survey forms was distributed among the people inside and nearby the Municipal hall. Participants of pre-tests are Municipal and Barangay officials, residents inside the Municipality, and households living beside and near the Municipal hall.

Survey Procedure

The researcher first visited the Municipal hall to give an introduction with a discussion about the research, including the materials and participants needed in the study. A pre-testing of survey form was allowed also at the same time. A letter of intent to conduct a survey, together with a letter from UST Graduate School, a brief description of the study, and a sample of the survey questionnaire was given to the Municipal Secretary. Briefing session with Municipal officials was conducted before the distribution of the survey questionnaire. The researcher went to the Municipal hall before the distribution of the survey questionnaires to meet the local officials and the Mayor. A short discussion with the Municipal officials, Faculty of local educational institutions and an assigned assistant was made to identify the place and schedule of the distribution of survey questionnaires.

On the actual survey, the representatives from the Romblon State University in San Fernando and Cajidiocan introduced the researcher to the Mayor of the municipality, the students and members of the faculty. The researcher personally gave the survey form to the respondents and gave a brief background of the research and the instructions of answering the survey form. In Magdiwang, the representative of the Department of Agriculture introduced the researcher to the Vice-Mayor since the Mayor was on leave. The researcher also gave the local officials and the faculty of the national high school and elementary school, local institutions, and households a brief background of the research. In some cases, the researcher and the assistant assisted and interviewed the participant after answering the form to ensure their knowledge about ecotourism in their municipality. One week of actual survey was assisted by Prof. Ricardo Romero and Mrs. Rose Romero both from Romblon State University – San Fernando Campus, Prof. Che Regala of Romblon State University – Cajidiocan Campus, Mr. Eugene Dianco of the Cajidiocan Municipal Hall, and Ms. Eya Ibabao of the Department of Agriculture – Magdiwang Office.

Data Analysis

The data from the survey was tabulated using Excel file and a table of the results was made. To analyze the perception of the residents towards Ecotourism, the study needs to use statistical treatment to interpret the results. The following statistical treatments will be used:

2.1. Percentage distribution
(%) = f/N x 100
Where: f = frequency of an item or response
N = total number of respondents

The percentage distribution will identify the number of frequencies in every item of the collected survey forms.

2.2 Weighted Mean

In getting the average of the answers derived from the survey forms, the researcher used weighted mean. This method will be used as a back-up analysis to determine the outcome of the survey.

To ensure the authenticity of the data stated in the survey form, the researcher eliminated questionnaires that are not completely answered.

Case Study Research

The case study approach directs the investigator to explore a case or cases over a period of time through a comprehensive data collection involving observations, interviews, audio-visual materials, documents and reports (Creswell, Hanson, Morales, & Plano, 2007). To get a more in-depth understanding and information in the Ecotourism project in the municipalities, the researcher utilized this kind of method to get a complete picture of the subjects.

Interview with Ecotourism Inter-Agency committee

The researcher conducted an interview with officials of the Department of Environment and Natural Resources and Department of Tourism offices in Romblon. The purpose of the interview is to identify the existence of Ecotourism programs in the Philippines; get a list of accredited

sites and criteria for selection; and to search on some interviews, journals, publications, and researches about local Ecotourism.

Participants

For Department of Tourism, the researcher interviewed Mr. Kim Anthony Faderon, the Provincial Tourism coordinator. For Department of Environment and Natural Resources, the researcher interviewed Mr. Thelmo Hernandez, the provincial forester.

The researcher also got the chance to meet Atty. Minerva Morada, the DOT Regional Director for Region 4-B and interviewed Ms. Hannah Tansiongco, a faculty member of the Romblon State University – San Fernando Campus and is also the provincial coordinator for ABS-CBN Foundation that actively promotes ecotourism in Sibuyan Island.

Procedure

The researcher visited the office of both DOT and DENR provincial offices to know the resource persons for the study and acquire the information about Ecotourism program.

Mode of Analysis

In the course of the interview, the researcher noted the key words that answer the researcher's questions and recorded the conversation through a voice recorder. Both agencies (DOT and DENR) referred the use of National Ecotourism Strategy which the researcher downloaded from the internet. The Provincial tourism office of Romblon also gave the researcher a comprehensive list of DOT accredited ecotourism sites of Sibuyan Island which can be found in Chapter 1.

Personal observations

Participant observation signifies the major methodology in data gathering in naturalistic settings. The researcher is expected to engage in activities appropriate to the situation, to observe the activities, people, and physical facets of the situation, and to establish a nonintrusive presence to perceive the events and participants in their natural areas for authenticity (Suzuki, 2007).

The observation has the advantage that leads the researcher to see behavior in a natural state that will provide a better prospect to classify aspects of behavior which is not possible to obtain through an interview (Suzuki, 2007). The observation type is an excellent basis to discover the physical structures, facilities, activities, and programs of an Ecotourism project and a rural community.

Participants

The researcher did an observation in San Fernando, the host community of Cantingas Eco-Adventure Zone, Cresta de Gallo, Busay and Lagting Falls, Lamao Lake, Dagubdob and Bilala Falls; Magdiwang, the gateway to Mt. Guiting-Guiting Natural Park, Marine Garden, Lambingan Falls, Dalipi River, Gaong River, and Ferrol Fish Sanctuary; and in Cajidiocan, the host community of Cawa-Cawa Falls, Little Baguio, and Sugod Fish Sanctuary to see the natural setting. The participant's observation in the Ecotourism project was done to know the physical characteristics of the project through available facilities and structure for obtaining the capacity of the venture. Different modes of observation were used by the researcher to gather data. The researcher was assisted by the Municipal officials and tour guides.

Instruments

The researcher conducted a personal observation within the place. The researcher observed the different businesses, infrastructure, livelihood, norms, the environment and state of life of the residents.

In San Fernando, the researcher stayed at the residence of Prof. and Mrs. Ricardo Romero, both from the faculty of Romblon State University. The researcher did an observation inside their barangay and went to different barangays to have an authentic experience on immersing with the locals. Prof. Romero hosted the researcher to the Cantingas Eco-Adventure Zone and gave a thorough background about the partnership of the local community, NGOs and the LGU in the promotion and progress of the area. The development of the Cantingas River also gave way to the installation of the second turbine generator which will upgrade the electricity consumption of Sibuyan to one hundred percent (100%) renewable in 2015.

In Cajidiocan, the researcher stayed at the residence of Prof. Che Regala. Mr. Eugene Dianco and Mr. Ariel Rabino acted as tour guides going to the Cawa-Cawa Falls and Biking Trail by means of mountain bikes which were for rent to have an authentic ecotourism experience. Crossing numerous rivers and trails are impossible for tourists without using mountain bikes which is why it is a developing business in Cajidiocan. The guides also gave a brief description of the ecotourism sites, livelihood of people, and future developments around the area. The researcher and the guides had their feast at a local restaurant in Poblacion.

In Magdiwang, the researcher stayed in the Nature View Lodge, a local lodging house to have a complete tourist's and researcher's experience. The researcher visited and feasted at the Sanctuary Garden Resort in Barangay. Tampayan which is the primary choice accommodation for high-end tourists. The researcher was able to get a complete picture of the tourism and service facilities through the help of the Magdiwang Tourism Office that oversees the ecotourism activities in the municipality. They offer packages and products from conventional tourist to hardcore tourist.

The areas visited have also been photographed for reference.

Procedure

In San Fernando, the researcher went to the Romblon State University and Municipal hall to introduce himself and to give the background of the research. The researcher gave documents including a letter from the UST Graduate School. A simple discussion about the municipality and research was done in the same day.

In Cajidiocan, the researcher went to the Romblon State University and Municipal hall to introduce himself and to give the background of the research. The researcher gave documents including a letter from the UST Graduate School. A simple discussion about the municipality and research was done in the same day.

In Magdiwang, the researcher went to the Municipal hall to introduce himself and to give the background of the research. The researcher gave documents including a letter from the UST Graduate School. A simple discussion about the municipality and research was done in the same day.

Mode of Analysis

Through the course of the observation, the researcher listened to the guides (tour guide and municipal officials). A field note was made on the spot by the researcher to inscribe the information observed and discovered within and outside the Ecotourism project. The data gathered from the municipality out of observation are transcribed and was made into a comprehensible data and used as reference. Photos from the project and the municipality were used to analyze some data.

Interview with Municipal Officials

Interviewing is one of the most significant qualitative data collection schemes. Interviewing is an important source of data for biographies, phenomenological studies, grounded-theory studies, ethnographic studies, and case-studies. The interview is not a communal contact of two people. The interviewer is expected to guide the situations, topics of conversations, and directions of conversation. The interviewer can obtain portrayals or descriptions of occurrences and can clarify and conclude the outcome throughout the interview session. Engaging in a rational and logical conversation between the interviewer and the interviewee are the main approaches that a researcher can choose from. Researchers can also get emotional descriptions of or reaction about a particular experience or event (Suzuki, 2007).

Participants

The interview for San Fernando was graced by Ms. Darryl Perez, the Municipal Planning and Development Officer and took place at her office. The interview for the Municipality of Cajidiocan was graced by Mr. Eugene Dianco, the tourism coordinator and took place at the Office of the Mayor. The interview for Magdiwang was graced by Sangguniang Bayan Member Nonoy Radan and Mr. Kim Anthony Faderon, the tourism coordinator from the Office of the Governor. The interview took place at a local coffee shop.

Instruments

An open-ended interview was conducted in each Municipal hall. The interview includes questions about the facilities, services, tourist arrival, activities, brief history, environmental practices and their programs to the community. The answers were recorded in the researcher's voice recorder and note book for easy retrieval.

Procedures

The researcher emailed the Municipal hall of San Fernando, Cajidiocan, and Magdiwang to inquire on the procedures on how to conduct the research. An email for request to conduct a research was also done together with a letter from the UST Graduate School; and the interview questionnaire was sent as supporting document. For San Fernando, the researcher was assisted by Prof. Ricardo Romero to the municipal hall and was introduced to Mayor Salem Tansingco. The Mayor endorsed the researcher to the MPDO. For Cajidiocan, Mr. Greggy Ramos, the son of the Mayor initially assisted the request before endorsing the concern to Mr. Eugene Dianco. The interview was done on the same day. For Magdiwang, the researcher visited the Magdiwang Tourism Office and was assisted by the secretary.

Mode of Analysis

In the process of interview, the researcher wrote the answers, key words, and was recorded consequently. The result was organized into a single file for analysis and for easy reference.

Documentary Analysis
Books on tourism, rural tourism, protected-area tourism, and community-based ecotourism were used as general references in this study. The National Ecotourism Strategy and Ecotourism books were used as the initial references for the study.

International Journals were also used as references for the study. The journals were used to have an in-depth understanding and analysis about the Ecotourism ventures existing around the world and their effects in rural communities. The
research design and survey questions were also taken from journals.

Socio-economic Profiles were utilized to get a more comprehensive data about the rural community. The researcher was able to get pertinent records from the Municipal Halls where the Ecotourism site is based. The records were retrieved from Provincial Tourism Office of Romblon and the Municipal Planning and Development Offices of San Fernando, Cajidiocan, and Magdiwang, Romblon.

Records on population, household, tourist arrival, other government statistics, and basic information were retrieved from the Provincial Tourism Office of Romblon, Department of Tourism library, and National Statistical Coordination Board (NSCB), Romblon State University Main Campus library.

Theses about Community-Based Ecotourism, rural tourism and rural community were also used as references. Some theses were found in the University of Santo Tomas library and Romblon State University Main Campus library.

Electronic references were also used to get some data related to Ecotourism and environmental preservation in Sibuyan Island and information about Ecotourism in the Philippines. Web pages of the province of Romblon and Sibuyan Island Sentinels League for Environment Inc. (Sibuyan ISLE) were utilized as basic references.

3. RESULTS AND DISCUSSIONS

This chapter will provide the comprehensive data acquired from the community's opinion on the outcome of Ecotourism in the municipality of San Fernando, Cajidiocan, and Magdiwang using the methodologies presented in the preceding chapter.

3.1 What are the positive and negative economic, ecological, and socio-cultural outcomes of ecotourism in the rural communities?

3.1.1. Ecotourism generates more business inside the Municipality such as small enterprises

According to the household survey, in San Fernando, 43.8% agree, 43.1% strongly agree, 10.6% disagree, and 2.5% strongly disagree that ecotourism generates more businesses in the community. The ABS-CBN Foundation coordinator and the municipal official said that because recognition is given to Cantingas River Eco-adventure zone, Dagubdob, Bila-Bila, and Lagting Falls, People's Organization and the local communities are able to cater meals for the visitors. They said that in recent years, the Ms. Earth candidates visited their tourist sites, planted mangroves and had their meals prepared by the locals. As observed there are stores and other business establishments around the tourist sites. The municipal official said that they have cooperative that manages the small and medium enterprises.

In Cajidiocan, 49.0% strongly agree, 47.6% agree, 3.5% disagree, and 0% strongly disagree that ecotourism generates more businesses in the community. The municipal official said that indeed, it creates small enterprises. The NGOs that visit their municipality conducts a tourism related trainings and livelihood programs for the locals to have a chance to enhance their skills in handicraft making and starting a business. The official said that this program is output based to monitor the participant's progress.

In Magdiwang, 45.7% strongly agree, 42.6% agree, 9.6% disagree, and 2.1% strongly disagree that ecotourism generates more businesses in the community. The provincial tourism official and the municipal councilor said that the presence of the major port in this municipality is the main reason why there is growing small enterprises within their municipality. Majority of the travelers also checks in the only DOT Accredited accommodation on the island thus making enterprises sustainable.

3.1.2. Ecotourism provides permanent jobs for the people in the Municipality

According to the household survey, in San Fernando, 60.6% agree, 24.4% disagree, 13.1% strongly agree, and 1.9% strongly disagree that ecotourism provides permanent jobs for the people in the municipality. The ABS-CBN Foundation coordinator and municipal official said that in Dagubdob, the local community has the sole management of the resort, making their locals work permanently for the maintenance and project development of the site. They said that the foundation provide tents, diving and hiking gears for the tourists to rent and then the income would be for the people's organization which includes the tour guides. However, during wet seasons when the visit of tourists is not at its peak, the ABS-CBN Foundation provides livelihood programs like gardening and livestock raising for the ecotourism workers.

In Cajidiocan, 54.5% agree, 25.9% disagree, 18.9% strongly agree, and .7% strongly disagree that ecotourism provides permanent jobs for the people in the municipality. The municipal official said that if the tourism industry will develop more in their municipality, it will help a lot of people through the jobs that it will create like in hotels and resorts. Right now, the municipality has various lodging houses and the most popular are The Mansion and The Marble Lodge which employs locals. Both are located in Poblacion.

In Magdiwang, 46.8% agree, 25.5% disagree, 22.3% strongly agree, and 5.3% strongly disagree that ecotourism provides permanent jobs for the people in the municipality. The provincial tourism official and the municipal councilor said that establishments in Magdiwang provide jobs for the people in their accommodation operations, restaurants, tour guiding, activity management and even in the port area. As an entry point, jobs pertaining to the transfer of tourist from the port to their accommodation provide additional income to the people.

3.1.3. Ecotourism provides short term jobs for daily workers in construction such as carpentry, plumbers, electrician, painter, etc.

According to the household survey, in San Fernando, 61.9% agree, 26.3% strongly agree, 8.1% disagree, 3.8% strongly disagree that ecotourism provides short term jobs for daily workers in construction. The municipal official said that the labor forces whenever there is a development project for the tourist sites are from the municipality.

In Cajidiocan, 62.2% agree, 28.0% strongly agree, 9.8% disagree, and 0% strongly disagree that ecotourism provides short term jobs for daily workers in construction. The municipal officer said

that because of the on-going road project of the government for tourism, the laborers in the locality were hired. The Germans and other locals owning a resort in the municipality employ natives for daily maintenance work.

In Magdiwang, 45.7% agree, 30.9% strongly agree, 19.1% disagree, and 4.3% strongly disagree that ecotourism provides short term jobs for daily workers in construction. The provincial tourism official and the municipal councilor said that establishments within the municipality hires labor force whenever there would be any need for new projects or rehabilitation. During peak seasons, short-term jobs are also offered by the accommodation establishments where they need additional workforce.

3.1.4. Jobs in Ecotourism are more profitable

According to the household survey, in San Fernando, 63.8% agree, 27.5% disagree, 6.3% strongly agree, and 2.5% strongly disagree that jobs in ecotourism are more profitable. The ABS-CBN Foundation coordinator and the municipal official said that due to the seasonality of tourist arrivals, many of the tourism related workers go back to farming when it is not peak season. But because of the prestige of working in resorts and as tour guides, many consider tourism as a profitable industry.

In Cajidiocan, 59.4% agree, 28.0% disagree, 9.1% strongly agree, and 3.5% strongly disagree that jobs in ecotourism are more profitable. The municipal official said before ecotourism came, mining was rampant in the municipality. The officer added that when the outcry to stop mining started and a lot of people realized the damage that their forests suffered, NGOs started to propose ecotourism as an alternative with the support of the LGU. They began to employ people from the community as partners in maintaining the environment. Some were hired as guides and drivers for tourists and visitors. Since ecotourism is still in its developing phase, they are optimistic that sooner or later, this industry will rise together with other industries such as agriculture and fisheries and replace the unsustainable mining.

In Magdiwang, 54.3% agree, 33.0% disagree, 6.4% strongly agree, and 6.4% strongly disagree that jobs in ecotourism are more profitable. As stated by the provincial tourism official, agriculture has been the major source of income for the people. The tourism industry is a new idea for everyone and this was positively embraced by the people. With the seasonality of the industry and frequent disturbance of natural calamities, the people would not totally rely on the profits generated from it. Still, the tourism sector serves as a good alternative livelihood for the interested locals in Magdiwang due to a number of activities offered in the municipality.

3.1.5. Ecotourism increases family income

According to the household survey, in San Fernando, 61.9% agree, 19.4% disagree, 16.3% strongly agree, and 2.5% strongly disagree that ecotourism increase family income. The municipal official said that because of the souvenir making, the women of the municipality generate extra income for the family. All families, with the help of the ABS-CBN Foundation, have their roles in maintaining the tourist sites in their area and with this, they are paid.

In Cajidiocan, 55.9% agree, 26.6% disagree, 16.8% strongly agree, and .7% strongly disagree that ecotourism increases family income. The municipal official said that families that had undergone trainings and other residents that have souvenir shops benefit from the visitors.

In Magdiwang, 58.5% agree, 22.3% disagree, 12.8% strongly agree, and 6.4% strongly disagree that ecotourism increases family income. The provincial tourism official and the municipal councilor said that livelihood trainings were given to different sectors of the community giving each an opportunity to increase their income. This is in partnership with ABS-CBN Foundation.

3.1.6. Ecotourism changed the jobs of the people from farming/fishing to tourism

According to the household survey, in San Fernando, 56.9% agree, 27.5% disagree, 13.1% strongly agree, and 2.5% strongly disagree that ecotourism changed the jobs of the people from farming or fishing to tourism. The municipal official said that there are no significant transfers of jobs from the primary sources of income to tourism. She said that agriculture is still the number one industry in their municipality. Tourism acts as an alternative to mining and other illicit extractive industries. However, a lot of people transfer to tourism when the peak season comes in, leaving their farming and fishing for a while.

In Cajidiocan, 54.5% agree, 32.2% disagree, 11.2% strongly agree, and 2.1% strongly disagree that ecotourism changed the jobs of the people from farming or fishing to tourism. The municipal official said that farming and fishing cannot be left behind. The residents still prioritize their primary source of sustenance in the form of agriculture and fishing. But the officer added that ecotourism plays the role as a good alternate job. Some fishermen act as guides and security for tourists who go swimming.

In Magdiwang, 54.3% agree, 29.8% disagree, 8.5% strongly agree, and 7.4% strongly disagree that ecotourism changed the jobs of the people from farming or fishing to tourism. The provincial tourism official said that agriculture is the main source of income for the people, in such, the majority of locals could not interchange jobs from farming and fishing to tourism but they could play minor roles such as guiding tourists during peak season. The municipal councilor furthered that because of the demand for sea foods, the fishermen are much more motivated to sell their catch in the market where tourists also go for shopping.

3.1.7. The development of Ecotourism increased yield of local products in your Municipality

According to the household survey, in San Fernando, 69.4% agree, 19.4% strongly agree, 6.9% disagree, and 4.4% strongly disagree that ecotourism has increased the yield of the municipality's locally produced products. The ABS-CBN Foundation coordinator and the municipal official said that the local products made by the local communities like "Nito Plates" and other products made of indigenous materials are shipped to Manila for sale. These products are ordered by some prominent individuals and families that support "Green products".

In Cajidiocan, 56.6% agree, 26.6% strongly agree, 16.8% disagree, and 0% strongly disagree that ecotourism has increased the yield of the municipality's locally produced products. The municipal official said that indeed, ecotourism helps a lot in their produce. The indigenous peoples from the mountains have regular buyers of their yields in the market due to tourism development. In the past, the IPs had been tricked by some other opportunistic vegetable sellers in the market by taking advantage of their uneducated background. But now everything has changed, the youths from these cultural minority groups are enrolled in local secondary and tertiary education institutions and some are studying in Romblon State University.

In Magdiwang, 48.9% agree, 26.6% disagree, 18.1% strongly agree, and 6.4% strongly disagree that ecotourism has increased the yield of the municipality's locally produced products. The

municipal councilor said that when the tourists came to their municipality, the farmers and fisher folks have been more motivated to double their yields to meet the increasing demand for local products.

3.1.8. The development of Ecotourism introduced new types of alternative livelihood

According to the household survey, in San Fernando, 60.6% agree, 23.1% strongly agree, 14.4% disagree, and 1.9% strongly disagree that ecotourism has introduced new types of alternative livelihood in the municipality. The ABS-CBN Foundation coordinator and the municipal official said that there are now tour guides and caterers based in the local community. In fact, some of the tricycle and jeepney drivers can be contracted as guides around the municipality or the whole island.

In Cajidiocan, 60.8% agree, 26.6% strongly agree, 11.9% disagree, and .7% strongly disagree that ecotourism has introduced new types of alternative livelihood in the municipality. The municipal official said that the residents are being oriented to the benefits that will be enhanced by ecotourism being pro-environment in nature. The official added that instead of cutting trees, preserving the forests and maximizing its beauty made an impact for the promotion of ecotourism in Sibuyan as a whole.

In Magdiwang, 54.3% agree, 23.4% disagree, 17.0% strongly agree, and 5.3% strongly disagree that ecotourism has introduced new types of alternative livelihood in the municipality. The provincial official said that as a major entry point, jeepney and tricycles drivers act as local tour guides for the travelers. More souvenir items for sale could be also seen in the town. The municipal councilor added that due to the development of ecotourism, they have seen many activities for the families who want to get involved in livelihood trainings.

3.1.9. The development of Ecotourism increased variety of handicrafts and souvenirs sold inside the Municipality

According to the household survey, in San Fernando, 56.9% agree, 26.9% strongly agree, 14.4% disagree, 1.9% strongly disagree that ecotourism increased the variety of handicrafts and souvenirs sold inside the municipality. The ABS-CBN Foundation coordinator and the municipality official said that souvenir and handicraft making is seen to be a growing business inside the municipality due to the coming of foreign tourists. They display these products in the market.

In Cajidiocan, 60.1% agree, 31.5% strongly agree, 7.0% disagree, and 1.4% strongly disagree that ecotourism increased the variety of handicrafts and souvenirs sold inside the municipality. The municipal official said that ecotourism really helped the families to increase their production of native handicrafts. An example of some native products is the skull of coconut crafted as “Sandok”, the vernacular term for spatula, coin purses, wallets with the name of Sibuyan Island, souvenir shirts, and the one they call “Kagagkag” or their version cassava delicacy.

In Magdiwang, 52.1% agree, 22.3% disagree, 17.0% strongly agree, and 8.5% strongly disagree that ecotourism increased the variety of handicrafts and souvenirs sold inside the municipality. The provincial tourism official and the municipal councilor said that there is a visible increase in the availability of souvenir items such as shirts and locally-produced handicrafts.

3.1.10. The development of Ecotourism increased the number of hotels/ motels/ apartelles within the Municipality

According to the household survey, in San Fernando, 40.6% agree, 37.5% disagree, 13.8% strongly disagree, and 8.1% strongly agree that ecotourism increased the number of lodging houses within the municipality. The municipal official said that there are 2 lodging houses under construction in Barangay. Poblacion. The ABS-CBN Foundation coordinator said that unlike Cajidiocan and Magdiwang, San Fernando was the last municipality to have lodging houses.

In Cajidiocan, 44.8% agree, 33.6% disagree, 14.7% strongly agree, and 7.0% strongly disagree that ecotourism increased the number of lodging houses within the municipality. The municipal official said that since the ecotourism is developing on the island, lodging houses and hotels are increasing in number and improving their services. But in terms of service standards, the LGU has no direct policy guidelines to set. Even so, these lodging houses offer their most natural act of hospitality.

In Magdiwang, 51.1% agree, 29.8% disagree, 10.6% strongly agree, and 8.5% strongly disagree that ecotourism increased the number of lodging houses within the municipality. The provincial tourism official said that Magdiwang is the most improved compared to San Fernando and Cajidiocan in the presence of an accredited accommodation. The owner set good standards in their operation making it more viable for different types of tourists. The municipal councilor added that from zero hotels in the past years, they have now the DOT accredited Sanctuary Garden Resort, Beach House Hotel, and Rancher's.

3.1.11. The development of Ecotourism increased the number of restaurants within the Municipality

According to the household survey, in San Fernando, 57.5% agree, 25.0% disagree, 12.5% strongly agree, and 5.0% strongly disagree that ecotourism increased the number of restaurants within the municipality. The ABS-CBN Foundation coordinator said that the presence of restaurants in their municipality is not as established compared to Cajidiocan and Magdiwang. But there are some eateries in the municipality that cater visitors and students.

In Cajidiocan, 49.7% agree, 25.9% strongly agree, 21.0% disagree, and 3.5% strongly disagree that ecotourism increased the number of restaurants within the municipality. The municipal official said that there is an increase in the number of eateries and food stalls in Poblacion. He added that eating in these eateries is clean and safe. One can truly experience their most simple cuisine.

In Magdiwang, 48.9% agree, 22.3% disagree, 21.3% strongly agree, and 7.4% strongly disagree that ecotourism increased the number of restaurants within the municipality. The provincial tourism official and the municipal councilor said that there is an increase in both local food stalls and restaurants within the municipality, from the local "Carinderias" or their budget eateries to restaurants and resto-bars. The municipality also ensures the sanitation of each establishment.

3.1.12. The development of Ecotourism increased the number of other recreational facilities such as swimming pools, etc.

According to the household survey, in San Fernando, 40.0% agree, 38.1% disagree, 13.1% strongly disagree, and 8.8% strongly agree that ecotourism increased the number of recreational

facilities such as a Zip-line, concrete pathways and trails, etc. The ABS-CBN Foundation coordinator and the municipal official said that there is no recreational facility such as swimming pool inside the municipality. The local and foreign tourists prefer to visit the natural pools beside the river and falls which have Zip-line, concrete pathways and trails.

In Cajidiocan, 51.7% agree, 31.5% disagree, 9.8% strongly agree, and 7.0% strongly disagree that ecotourism increased the number of recreational facilities inside the municipality. The municipal official said that regardless of the tourism development, they still prioritize sports development through recreational facilities such as basketball courts and other sports facilities. The LGU has enough savings to spend on sporting activities.

In Magdiwang, 43.6% disagree, 33.0% agree, 14.9% strongly disagree, and 8.5% strongly agree that ecotourism increased the number of recreational facilities inside the municipality. The provincial tourism official and the municipal councilor said that there is no major increase in recreational facility but the accommodation establishment provides firefly watching, kayaking tours, natural dam swimming pool and DENR owned swimming pool at the foot of Mt. Guiting-Guiting.

3.1.13. The development of Ecotourism helps the Municipality to have a better road condition

According to the household survey, in San Fernando, 47.5% agree, 28.1% strongly agree, 20.0% disagree, and 4.4% strongly disagree that ecotourism helps the municipality to have a better road infrastructure. The municipal official said that the circumferential road is underway and is expected to be completed by the year 2016 since the other islands have their roads finished by the provincial government like in Tablas and Romblon Islands.

In Cajidiocan, 53.8% agree, 30.1% strongly agree, 14.0% disagree, and 2.1% strongly disagree that ecotourism helps the municipality to have a better road infrastructure. The municipal official said that the 1.2 billion national road projects for the whole Sibuyan Island for the year 2015 is underway. He added that the project is intended for tourism development. There is also a 65 million ecotourism road project paving the way to the famous Cawa-Cawa Falls in Barangay. Lumbang Weste. The municipal official and I inspected the area and witnessed the ongoing construction. It is also expected to boost commerce since it will serve as farm to market road.

In Magdiwang, 52.1% agree, 19.1% strongly agree, 19.1% disagree, and 9.6% strongly disagree that ecotourism helps the municipality to have a better road infrastructure. The municipal councilor said that four years ago, the road condition was downright dreadful. But now with the completion of the Tablas Island road projects, the circumferential road of the whole Sibuyan Island is being fast-tracked. As observed, only a few municipal thoroughfares are not concrete.

3.1.14. The development of Ecotourism helps the Municipality to have a better water supply

According to the household survey, in San Fernando, 58.8% agree, 21.9% strongly agree, 15.6% disagree, 3.8% strongly disagree that ecotourism helps the municipality to have a better water supply. The ABS-CBN Foundation coordinator and the municipal official said that because of the Cantingas River and other natural springs inside the municipality, they have no problems when it comes to irrigation and household use of water.

In Cajidiocan, 60.8% agree, 25.2% strongly agree, 13.3% disagree, and .7% strongly disagree that ecotourism helps the municipality to have a better water supply. The municipal official said

that Sibuyan is rich in water supply, the only problem encountered is the remoteness of sources and budget but he said further that the DILG together with DOH presented a budget of 7 million pesos to improve the water systems in the municipality. The tourism development drives the LGU to prioritize the basic prerequisites for investors to invest in their municipality.

In Magdiwang, 50.0% agree, 24.5% disagree, 20.2% strongly agree, and 5.3% strongly disagree that ecotourism helps the municipality to have a better water supply. The provincial tourism official said that this is a major need for tourism development and Sibuyan is known for its abundant water supply. The only problem that arises is the proper distribution of the water throughout the municipality; the government must invest on this to properly address the problem. The municipal official said that the local government has allocated a 55-million peso rehabilitation project for their water supply.

3.1.15. The development of Ecotourism helps the Municipality to have a better telecommunication facility

According to the household survey, in San Fernando, 56.9% agree, 23.8% strongly agree, 15.0% disagree, and 4.4% strongly disagree that ecotourism helps the municipality to have better communication facilities. The municipal official said that their Smart satellite was built in 2006 and Globe satellite in 2007. During this period, the tourism on the island made a sound throughout the province.

In Cajidiocan, 58.7% agree, 30.8% strongly agree, 9.8% disagree, and .7% strongly disagree that ecotourism helps the municipality to have a better communication facilities. The municipal official said that so far, Globe Telecom has upgraded their service 2G to 3G. Smart has also a facility in the municipality and is also refining their services.

In Magdiwang, 45.7% agree, 27.7% strongly agree, 17.0% disagree, 9.6% strongly disagree that ecotourism helps the municipality to have a better communication facilities. The provincial tourism official and the municipal councilor said that both Smart and Globe Telecom provide a high speed, 3G, wireless connectivity together with GSM facilities. With this basic need for travelers, the infrastructure might improve together with the influx of travelers.

3.1.16. Ecotourism helps the Municipality to be aware of the importance of their natural environment

According to the household survey, in San Fernando, 56.9% strongly agree, 35.0% agree, 6.9% disagree, and 1.3% strongly disagree that ecotourism helps the municipality to be aware of the importance of their natural environment. The municipal official said that there are policies within the tourist sites that prohibit the visitors to throw their trash on the area. Various NGOs, People's Organizations, local parishes, and all communities voted against mining and other extractive and degrading industries. The people of San Fernando respect and love their environment.

In Cajidiocan, 58.7% strongly agree, 39.2% agree, 2.1% disagree, and 0% strongly disagree that ecotourism helps the municipality to be aware of the importance of their natural environment. The municipal official said that even before ecotourism was introduced in their municipality, there are outcries and campaigns to curve out environmental degradation and enhance environment conservation and protection. He added that the people of Sibuyan are well-informed and educated about the proper use of ecotourism and the practice of sustainability.

In Magdiwang, 51.1% strongly agree, 37.2% agree, 7.4% disagree, and 4.3% strongly disagree that ecotourism helps the municipality to be aware of the importance of their natural environment. The provincial tourism official said and the municipal councilor said that even before the booming of the industry, different sectors of the society have been active in opposing to any activities that would degrade the environment. The industry just made a manifestation that there can be a form of investment that will help improve and conserve nature. The LGU is also keen on implementing the carrying capacity of Mt. Guiting-Guiting which is 50 hikers per day to control the flow of tourists. The municipal councilor added that with ecotourism, they can protect the environment and earn at the same time

3.1.17. Ecotourism helps the Municipality to preserve and protect their natural environment

According to the household survey, in San Fernando, 55.0% strongly agree, 38.1% agree, 5.0% disagree, and 1.9% strongly disagree that ecotourism helps the municipality to preserve and protect their natural environment. The ABS-CBN Foundation coordinator said that are over lapses on the territory of the Indigenous People and the Protected Areas under DENR's NIPAS law. They had a dilemma in the past that these cultural minorities allegedly sell timbers for commerce and insist that it is their right according to their ancestral domain. But, generally speaking, the municipality has high respect for their natural environment and will do everything to protect and conserve their treasure.

In Cajidiocan, 53.1% strongly agree, 42.0% agree, 4.9% disagree, and 0% strongly disagree that ecotourism helps the municipality to preserve and protect their natural environment. The municipal official said that ecotourism has become an important tool to change the perspective of the people about their environment. Their drive against mining and other exploitative means of getting income through environment made a way for ecotourism to become an alternative and a more sustainable tool of development. The municipality's Idioc festival showcases their appreciation and awareness for this sustainable tool and promotes it by the annual Ms. Sibuyan Ecotourism Beauty Pageant. The official added that with ecotourism, they can sell the beauty of their environment by just experiencing oneness in nature, appreciating its splendour, and learning the importance of preservation and protection for the benefit of the future generations.

In Magdiwang, 47.9% strongly agree, 40.4% agree, 8.5% disagree, and 3.2% strongly disagree that ecotourism helps the municipality to preserve and protect their natural environment. The provincial tourism official and the municipal councilor said that with the activities such as firefly watching, kayaking, hiking and the others, the community is even more active for the preservation of their environment for the benefit of the next generation and for the sustenance of such activities.

3.1.18. Ecotourism opens employment and livelihood for women

According to the household survey, in San Fernando, 57.5% agree, 21.3% disagree, 18.1% strongly agree, and 3.1% strongly disagree that ecotourism opens employment and livelihood for women. The municipal official said that the women involvement in tourism activities has helped them develop products such as souvenirs and other handicrafts available for visitors and that provides them extra income.

In Cajidiocan, 60.8% agree, 22.4% strongly agree, 15.4% disagree, and 1.4% strongly disagree that ecotourism opens employment and livelihood for women. The municipal official said that through the livelihood trainings that were conducted which the women participated, a lot of them

benefitted by enhancing their skills and knowledge. The government exerted efforts to support and showcase the indigenous products of their municipality.

In Magdiwang, 56.4% agree, 22.3% disagree, 13.8% strongly disagree, and 7.4% strongly disagree that ecotourism opens employment and livelihood for women. The municipal councilor said that women are now becoming more involved in tourism activities. In partnership with Technical Education and Skills Development Authority (TESDA), seminars and trainings for them are being implemented such as: skirting of tables, party needs, food and beverage, and manicure and pedicure which all happened last December 2014. The LGU has also donated "chairs for rent" for the women's organization. All of these activities are for women empowerment.

3.1.19. Ecotourism provides part-time job for students during weekends and school holidays

According to the household survey, in San Fernando, 46.9% agree, 26.9% disagree, 16.9% strongly agree, and 9.4% strongly disagree that ecotourism provides part-time job for students. The ABS-CBN Foundation and the municipal official said that the students that apply serve as tour guides during summer seasons. The students are paid per day and they are also trained.

In Cajidiocan, 65.0% agree, 20.3% strongly agree, 13.3% disagree, and 1.4% strongly disagree that ecotourism provides part-time job for students. The municipal official said that during summer seasons, students get the chance to work as part-time workers for some of the resort owners in the municipality.

In Magdiwang, 50.0% agree, 23.4% disagree, 17.0% strongly agree, and 9.6% strongly disagree that ecotourism provides part-time jobs for students. The provincial tourism official said that accommodation establishments hire students for part-time jobs particularly during peak seasons. The municipal councilor furthered that when they had a councilor's league convention, which is a form of tourism since it belongs to Meetings, Incentives, Conventions, and Exhibitions (MICE), they hired students from RSU as staff and ushers. Some councilors even sponsored these students on their tertiary education as scholars.

3.1.20. Ecotourism helps the Municipality to have a sense of pride in their culture

According to the household survey, in San Fernando, 48.8% strongly agree, 43.8% agree, 4.4% disagree, and 3.1% strongly disagree that ecotourism helps the municipality to have a sense of pride for their customs and culture. The municipal official said that because of the natural beauty of their island, they become really proud to be a "Sibuyanon". Having direct contact with the tourists, the tour guides as the ambassadors of Sibuyan are trained to be well-informed and passionate about their culture.

In Cajidiocan, 52.4% strongly agree, 46.2% agree, 1.4% disagree, and 0% strongly disagree that ecotourism helps the municipality to have a sense of pride for their customs and culture. The municipal official said that there is now a celebration of the IP communities in the municipality. Recently, they conducted a recognition day which enabled the cultural minority group or the Sibuyan Mangyan Tagabukid to parade together with the municipal officials and Sibuyan Community Service Center of National Commission on Indigenous Peoples – Region 4 to showcase their local customs and culture by wearing their primitive wears, exhibiting their products and yields.

In Magdiwang, 48.9% agree, 41.5% strongly agree, 7.4% disagree, and 2.1% strongly disagree that ecotourism helps the municipality to have a sense of pride for their customs and culture. The municipal councilor said that the locals are proud of their customs and culture. In the onset of tourism, they can showcase their pride and exhibit the beauty of their culture. The councilor added that through social media many Sibuyanons abroad became more proud of their heritage because of the updates on the local events, developments, and increasing popularity of the island. In the past years, the island has been visited by various travel shows like Pinoy Adventures, hosted by Richard Gutierrez.

3.1.21. Ecotourism helps the Municipality to preserve and protect their culture

According to the household survey, in San Fernando, 46.3% agree, 41.9% strongly agree, 6.3% disagree, and 5.6% strongly disagree that ecotourism helps the municipality to preserve and protect their culture. The ABS-CBN Foundation coordinator and the municipal official said that with this kind of awareness brought by ecotourism, it is indeed a helpful motivation to protect their local customs and culture.

In Cajidiocan, 52.4% agree, 42.0% strongly agree, 5.6% disagree, and 0% strongly disagree that ecotourism helps the municipality to preserve and protect their culture. The municipal official said that with the introduction of ecotourism in the municipality, the IPs and the people from the barangays became aware not just the importance of their environment but also their culture and will do everything to preserve it. With this result, the visitors also pay respect to their culture and traditions. Example of this is the coming of German communities in their municipality. These foreigners have high respect for the local customs and are willing to preserve it by being customers of the products and labour of locals.

In Magdiwang, 55.3% agree, 34.0% strongly agree, 9.6% disagree, and 1.1% strongly disagree that ecotourism helps the municipality to preserve and protect their culture. The municipal councilor said that because of the growing respect for their island's rich cultural and biophysical diversity, the locals gained more motivation to protect their natural assets.

3.1.22. Ecotourism increased settlement of people in the Municipality

According to the household survey, in San Fernando, 58.1% agree, 20.0% disagree, 17.5% disagree, and 4.4% strongly disagree that ecotourism increased the settlement of people in the municipality. The municipal official said that a number of Germans has established German communities in their municipality. These foreigners have a lease agreement with the locals for the lot and payable in 25 years. Others are married to Filipinos. Migrants from Masbate and Capiz also flock the San Fernando area because of the abundance of natural resources and sea catch.

In Cajidiocan, 58.7% agree, 23.1% strongly agree, 18.2% disagree, and 0% strongly disagree that ecotourism increased the settlement of people in the municipality. The municipal official said that many of their "Kasimanwas" or their vernacular term for natives returns home from the cities to establish their homes permanently. Some choose to return because of the growing popularity of the island from investors and interested buyers of land.

In Magdiwang, 55.3% agree, 22.3% disagree, 13.8% strongly agree, and 8.5% strongly disagree that ecotourism increased the settlement of people in the municipality. The provincial tourism official said that the scenario in Magdiwang is almost the same in San Fernando and Cajidiocan.

The local people return home after years of working in the city or abroad and invest their money in their hometown. The municipal councilor added that people from Masbate and Capiz went also in Sibuyan in the early 80s to take refuge during inclement weather and eventually saw the beauty of the island.

3.1.23. Ecotourism decreases urbanization

According to the household survey, in San Fernando, 53.8% agree, 28.1% disagree, 10.6% strongly agree, and 7.5% strongly disagree that ecotourism decrease urbanization and that the locals prefer to stay in San Fernando. The municipal official said there are some who are still migrating to the cities looking for better work and education among other reasons.

In Cajidiocan, 58.7% agree, 27.3% disagree, 14.0% strongly disagree, and 0% strongly disagree that ecotourism decrease urbanization. The municipal official said that instead of going somewhere else to live, the people tend to stay in the municipality because of its complete institutions. The Romblon State University – Cajidiocan Campus, health services, and government offices to name a few, cater to the needs of the locals.

In Magdiwang, 46.8% agree, 30.9% disagree, 12.8% strongly agree, and 9.6% strongly disagree that ecotourism decrease urbanization. The provincial tourism official and the municipal councilor said that there are still some people migrating to other areas to look for better jobs and education. But after few years, they will eventually return home and live in the municipality permanently.

3.1.24. The development of Ecotourism helps the Municipality to have a better health service

According to the household survey, in San Fernando, 57.5% agree, 20.6% strongly agree, 15.6% disagree, and 6.3% strongly disagree that ecotourism helps the municipality to have a better health service. The municipal official said that it is the priority service of the LGU. Regardless of the development of ecotourism, the health service delivery is a top priority. The affirmative responses of the respondents are based on the presence of German communities who also go to their hospital.

In Cajidiocan, 58.0% agree, 24.5% strongly agree, 16.8% disagree, and .7% strongly disagree that ecotourism helps the municipality to have a better health service. The municipal official said that so far he has not seen any improvements in direct relation to ecotourism. But the service of the hospital has improved since there is an increase of number of residents including foreigners.

In Magdiwang, 56.4% agree, 18.1% strongly agree, 18.1% disagree, and 7.4% strongly disagree that ecotourism helps the municipality to have a better health service. The provincial tourism official and the municipal councilor said that the health services improved in the municipality but majority of the patients would still proceed to Manila for specialized treatments.

3.1.25. Ecotourism increased traffic jam inside the Municipality

According to the household survey, in San Fernando, 43.1% disagree, 26.9% strongly disagree, 25.0% agree, and 5.0% strongly agree that ecotourism has increased traffic congestions inside the municipality. The municipal official said that they did not encounter any traffic congestion since the primary modes of transportation around the island are motorcycles, tricycles, and jeepneys.

In Cajidiocan, 42.0% disagree, 28.0% agree, 25.9% strongly disagree, and 4.2% strongly agree that ecotourism has increased traffic congestions inside the municipality. The municipal official said that traffic is not a problem in their municipality since majority of the vehicles is motorcycles. But he added that when sea vessels are being disembarked at the port is the only time when they experience moderate to heavy traffic.

In Magdiwang, 45.7% disagree, 26.6% strongly disagree, 18.1% agree, and 9.6% strongly agree that ecotourism has increased traffic congestions inside the municipality. The provincial tourism official and the municipal councilor said that there is no traffic related problem within the municipality.

3.1.26. Ecotourism increased cost of living in the Municipality

According to the household survey, in San Fernando, 45.6% disagree, 37.5% agree, 10.0% strongly disagree, and 6.9% strongly agree that ecotourism has increased the cost of living in the municipality. The municipal official said that ecotourism did not affect the cost of living in the municipality. The ABS-CBN Foundation coordinator said that their simple way of life remains the same even if there is now the presence of tourists and other migrants, local or foreigners.

In Cajidiocan, 42.0% agree, 40.6% disagree, 11.9% strongly disagree, and 5.6% strongly agree that ecotourism has increased the cost of living in the municipality. The municipal official said that the lifestyle of the locals remains to be simple. But because of some developments in the telecommunications like the internet, majority of the respondents which are students confirmed that there is a slight upgrade on their lifestyle.

In Magdiwang, 46.8% disagree, 31.9% agree, 12.8% strongly disagree, and 8.5% strongly agree that ecotourism has increased the cost of living in the municipality. The provincial tourism official and the municipal councilor said that the industry did not affect the cost of living in the municipality. The change of lifestyle did change how people manage their cost of living.

3.1.27. Ecotourism makes house rentals expensive

According to the household survey, in San Fernando, 41.9% agree, 37.5% disagree, 13.8% strongly disagree, and 6.9% strongly agree that ecotourism makes house rentals expensive. The municipal official said that ecotourism did not increase or affect majority of the house rentals in the municipality. Only those which cater to tourists increase rental fees because of the demand.

In Cajidiocan, 53.1% agree, 31.5% disagree, 8.4% strongly disagree, and 7.0% strongly agree that ecotourism makes house rentals expensive. According to the municipal official, due to the demand in renting space to students of the Romblon State University – Cajidiocan Campus, some apartment owners have increased their rent. The house owners also tend to raise the rent for tourists.

In Magdiwang, 39.4% agree, 35.1% disagree, 12.8% strongly disagree, and 12.8% strongly agree that ecotourism makes house rentals expensive. The provincial tourism official and the municipal councilor said that house rentals did not increase for the locals. But the house owners increased their rent for the foreign tourists.

3.1.28. Ecotourism increased the cost of land inside the Municipality

According to the household survey, in San Fernando, 42.5% agree, 33.1% disagree, 16.3% strongly agree, and 8.1% strongly disagree that ecotourism has increased the cost of land inside the municipality. The municipal official said that ecotourism did not increase or affect the cost of land in the whole municipality. But in the areas near the Cantingas River, Bila-Bila and Dagubdob Falls, there is a slim increase in land cost.

In Cajidiocan, 50.3% agree, 30.1% disagree, 15.4% strongly agree, and 4.2% strongly disagree that ecotourism has increased the cost of land inside the municipality. The municipal official said that since the German communities came, the landowners have established their own land value standards which these foreigners lease. The official said that the most costly lands are near the beach.

In Magdiwang, 51.1% agree, 26.6% disagree, 12.8% strongly agree, and 9.6% strongly disagree that ecotourism has increased the cost of land inside the municipality. The municipal councilor said that because of the development of the certain areas like parcel of lands near the beach or near at road networks, it is likely to increase its cost.

3.1.29. Ecotourism increased the price of locally produced goods

According to the household survey, in San Fernando, 48.8% agree, 30.6% disagree, 13.8% strongly agree, and 6.9% strongly disagree that ecotourism has increased the price of local products inside the municipality. The ABS-CBN Foundation coordinator and municipal official said that for some vendors and businesses, increasing their prices for souvenirs and other indigenous products is reasonable for them because the tourists could still buy their products. But for the local customers, there is no increase in the price of products.

In Cajidiocan, 52.4% agree, 28.7% disagree, 13.3% strongly agree, and 5.6% strongly disagree that ecotourism has increased the price of local products inside the municipality. The municipal official said that only those produce from the mountains scarcely be controlled by the Department of Trade and Industry. The yields of the farmers from far-flung areas have seen an increased cost linked from the coming of local and foreign tourists.

In Magdiwang, 39.4% disagree, 36.2% agree, 13.8% strongly disagree, and 10.6% strongly agree that ecotourism has increased the price of local products inside the municipality. The municipal councilor said that there has been no increase in the price of the local products. If there is some increase, it is on meat products and can be justified by of the law of supply and demand.

3.1.30. Ecotourism increased the price of commodities sold in a local shop

According to the household survey, in San Fernando, 42.5% agree, 37.5% disagree, 14.4% strongly agree, and 5.6% strongly disagree that ecotourism has increased the price of commodities sold in local stores. The ABS-CBN Foundation coordinator and municipal official said that ecotourism is not the sole reason for the increase of price of commercial products in the municipality, there are other factors affecting the increase such as bad weather which affects the yield of crops and other agricultural products.

In Cajidiocan, 51.0% agree, 33.6% disagree, 10.5% strongly agree, and 4.9% strongly disagree that ecotourism has increased the price of commodities sold in local stores. The municipal official said that there is no significant increase in prices but because of the coming of tourists and their demand for local products, there is a minimal escalation of prices.

In Magdiwang, 44.7% agree, 35.1% disagree, 12.8% strongly disagree, and 7.4% strongly agree that ecotourism has increased the price of commodities sold in local stores. The provincial tourism official and the municipal councilor said that the price of basic commodities increased because of suppliers come from other places. The presence of the industry didn't escalate prices but rather increased the demands.

3.1.31. Ecotourism increased air pollution in the Municipality

According to the household survey, in San Fernando, 47.5% disagree, 28.1% strongly disagree, 19.4% agree, and 5.0% strongly agree that ecotourism has increased the air pollution in the municipality. The municipal official said that the municipality doesn't have air pollution since their roads are not congested and air is filtered through the forests.
In Cajidiocan, 55.2% disagree, 21.7% strongly disagree, 19.6% agree, and 3.5% strongly agree that ecotourism has increased the air pollution. The municipal official said that the municipality has no direct cause of air pollution. The Poblacion which is the center of commerce and which is most likely to have air pollution doesn't seem to show that air pollution is present in the municipality.

In Magdiwang, 45.7% disagree, 29.8% strongly disagree, 14.9% agree, and 9.6% strongly agree that ecotourism has increased the air pollution. The provincial tourism official said that since a majority of the area is forested, the air could be easily filtered. The municipal councilor said that they also implement strict regulations on different forms of pollutions and contaminations.

3.1.32. Ecotourism increased noise inside the Municipality

According to the household survey, in San Fernando, 41.9% disagree, 26.9% agree, 25.6% strongly disagree, and 5.6% strongly agree that ecotourism has increased the noise inside the municipality. The municipal official said that ecotourism did not increase noise inside the municipality. There are plenty of tourists, but they respect other residents,

In Cajidiocan, 53.8% disagree, 22.4% agree, 17.5% strongly disagree, and 6.3% strongly agree that ecotourism has increased the noise inside the municipality. The municipal official said that ecotourism doesn't seem to be a maker of noise. The German community in the shoreline area wants a noise-free environment. He added that the municipality has maintained peace and order which they are really proud of.

In Magdiwang, 53.2% disagree, 23.4% strongly disagree, 13.8% agree, and 9.6% strongly agree that ecotourism has increased the noise inside the municipality. The provincial tourism official and the municipal councilor said that travellers would want to have a serene and peaceful environment thus they maintain activities that would create less noise.

3.1.33. Ecotourism makes the Municipality surrounding dirty

According to the household survey, in San Fernando, 50.6% disagree, 25.0% strongly disagree, 20.6% agree, and 3.8% strongly agree that ecotourism makes the surrounding in the municipality dirty. The municipal official said that ecotourism did not make the surrounding in the municipality dirty. The locals respect the cleanliness of their environment.

In Cajidiocan, 58.0% disagree, 23.8% strongly agree, 14.0% agree, and 4.2% strongly disagree that ecotourism makes the surroundings in the municipality dirty. The municipal official said the

tourists actually initiate cleanliness; they are those who are committed to promoting a clean and green environment which is likely the reason why they visit the municipality. The official added that the residents are well oriented and disciplined.

In Magdiwang, 55.3% disagree, 23.4% strongly disagree, 16.0% agree, and 5.3% strongly agree that ecotourism makes the surroundings in the municipality dirty. The provincial tourism official said that the people have been aware of the effects of pollution thus making everyone committed in cleanliness. The municipal councilor said that they are practicing segregation and proper disposal of wastes.

3.1.34. Ecotourism destroys the natural environment

According to the household survey, in San Fernando, 47.5% disagree, 35.6% strongly disagree, 15.0% agree, and 1.9% strongly agree that ecotourism destroys the natural environment. The municipal official said that so far they did not encounter any environmental degradation with tourism development. The residents who also visit and enjoy the various rivers, falls and beaches are well-disciplined.

In Cajidiocan, 55.2% disagree, 30.8% strongly disagree, 10.5% agree, and 3.5% strongly agree that ecotourism destroys the natural environment. The municipal official said that most of the tourist destinations in the municipality have no entrance fees yet, so it is expected that everyone can enter these areas. Through barangay assemblies, the locals are educated and oriented to respect the tourist destinations and that they should refrain from vandalism, littering, and other forms of offense which will affect the environment. The official added that although the road projects of the DPWH are on-going and may have damaged mangrove areas, the agency assured that they will replace these affected areas. In the island of Sibuyan, Cajidiocan is the only municipality that has mangrove nurseries which holds the total of 5000 mangrove reserves ready for plantation which is part of their ecotourism initiatives.

In Magdiwang, 48.9% disagree, 34.0% strongly disagree, 10.6% agree, and 6.4% strongly agree that ecotourism destroys the natural environment. The provincial tourism official and the municipal councilor said that with the proper guidance of authority, there has been no damage to the environment. Travellers are also educated and instructed not to vandalize or do anything that would degrade the environment.

3.1.35. Ecotourism increased crime rate

According to the household survey, in San Fernando, 40.0% disagree, 34.4% strongly disagree, 21.3% agree, and 4.4% strongly agree that ecotourism has increased the crime rate in the municipality. The municipal official said that they did not encounter any crime incident related to tourism. Peace and order is in place and the police forces in the area are active. The ABS-CBN Foundation coordinator said that whenever there are lost properties like cell phones and other belongings, they are returned to the owner or in the municipal hall.

In Cajidiocan, 59.4% disagree, 23.1% strongly disagree, 14.0% agree, and 3.5% strongly agree that ecotourism has increased the crime rate in the municipality. The municipal official said that there is no tourism-related incident or crime. They have a dependable peace and order system that secures the whole municipality.

In Magdiwang, 46.8% disagree, 38.3% strongly disagree, 11.7% agree, and 3.2% strongly agree that ecotourism has increased the crime rate in the municipality. The provincial tourism official and the municipal councilor said that the town has zero tourism-related crimes. The councilor added that their prison cells are all empty.

3.1.36. Ecotourism destroys the local custom and culture

According to the household survey, in San Fernando, 46.9% disagree, 35.0% strongly disagree, 14.4% agree, and 3.8% strongly agree that ecotourism destroys the local custom and culture. The municipal official said that ecotourism did not destroy their culture. They have respect for the locals especially the Indigenous Peoples (IPs) living in the mountains. These cultural minorities are protected under national laws of the Philippines.

In Cajidiocan, 59.4% disagree, 29.4% strongly disagree, 7.0% agree, and 4.2% strongly agree that ecotourism destroys the local custom and culture. The municipal official said that ecotourism did not at any point destroy the local customs and culture; instead it became a tool for the municipality's cultural awareness by conducting events which showcase and encourage the different IP communities. Ecotourism in Cajidiocan has become an engine for people empowerment and participation.

In Magdiwang, 46.8% disagree, 37.2% strongly disagree, 11.7% agree, and 4.3% strongly agree that ecotourism destroys the local custom and culture. The municipal councilor said that ecotourism even helped the municipality gain appreciation and respect from the social media due to its utmost care for the environment engrained in their rich culture.

3.1.37. Ecotourism project in my Municipality is successful

According to the household survey, in San Fernando, 68.1% agree, 20.0% disagree, 11.9% strongly agree, and 0% strongly disagree that ecotourism projects are successful in the municipality. The ABS-CBN Foundation coordinator and the municipal official said that ecotourism isn't much a priority, unlike agriculture. However, because of the clamour of the people to fight mining and find better ways to maximize their natural resources without the destruction of the environment, the municipality and various Non-Government Organizations have developed their tourist spots. The project includes the Cantingas River Eco-adventure Zone and Dagubdob Falls which helped the municipality and barangay to generate income while making sure that the benefits trickle down to the local community. As observed, the employees and the caretaker of these tourist spots are locals. For San Fernando, Tourism may be viewed as a means to enhance the value of agriculture and forest resources and be considered as an alternative to destructive agricultural, fishing and other resource extractive industries. Eco-tourism development should be managed because it is environmentally, culturally and socially accepted, meaning it is responsible and sustainable. It is indeed successful for the LGU and local communities to have benefits of this kind of development without the risk of losing their natural environment.

In Cajidiocan, 67.1% agree, 18.9% strongly agree, 13.3% disagree, and .7% strongly disagree that ecotourism projects are successful in the municipality. The municipal official said that their annual Idioc Festival and the commemoration of The Battle of Sibuyan Sea showcases their rich ecotourism treasures; their tourist destinations like their beaches, Cawa-Cawa Falls, Little Baguio Falls, and Sugod Fish Sanctuary to name a few, are their source of pride. Their lush forests and mountains which are home for diverse indigenous communities are protected and

managed by tribe leaders in coordination with the NCIP and DENR. Ecotourism also became a tool for business in the municipality and an alternative industry to mining. Many residents built their own businesses in response to the coming of visitors in their municipality. The production of local products and souvenir items has been increased. This harmony shows the success of the ecotourism development which encourages the locals' participation to preserve and protect their rights to have a good livelihood, clean environment, and vibrant and harmonious society through people empowerment.

In Magdiwang, 50.0% agree, 28.7% disagree, 14.9% strongly agree, and 6.4% strongly disagree that ecotourism projects are successful in the municipality. The provincial tourism official said that ecotourism has been a successful venture in Magdiwang with the presence of different ecotourism activities such as firefly watching, hiking, kayaking and swimming in natural pools. Also, majority of the trainings, regional, provincial and local level, are held at Sanctuary Garden. Sanctuary Garden has been also accredited by DOT as a resort. But the municipal councilor added that there is still a lot of work that should be done for more successful ecotourism activities.

3.1.38. Ecotourism attract more tourists

According to the household survey, in San Fernando, 48.1% agree, 41.9% strongly agree, 8.1% disagree, and 1.9% strongly disagree that ecotourism attract more tourists. The ABS-CBN Foundation coordinator and the municipal official said that a lot of local and foreign tourists now are present in their municipality. Particularly, Germans have established their own rest houses, which are leased from the LGU. But due to the condition of the road and bridge infrastructures and ports that would serve big vessels coming from Batangas or even Manila, the tourists from other parts of the Philippines are having difficulty in choosing Sibuyan. However, because of the on-going projects of the DPWH to develop the circumferential roads and bridges; including the opening of the airport construction in Barangay. Azagra, it will surely boost the tourist arrivals and would open the island for more tourists and investors.

In Cajidiocan, 53.1% strongly disagree, 40.6% agree, 5.6% disagree, and .7% strongly disagree that ecotourism attracts more tourists. The municipal official said that it is true that ecotourism attracts more visitors in their municipality and Sibuyan as a whole because of their rich natural resources, majestic landscapes and seascapes, undisturbed habitats, unique waterfalls, and vibrant and hospitable local communities which the tourists would love to encounter and learn from.

In Magdiwang, 51.1% agree, 28.7% strongly agree, 18.1% disagree, and 2.1% strongly disagree that ecotourism attracts more tourists. The provincial tourism official said that with the online presence and endorsement from other backpackers, more travelers include Sibuyan in their itinerary. The municipal councilor said that in January and February alone, they have booked 300 foreign and domestic tourists.

3.1.39. Ecotourism makes the Municipality attractive

According to the household survey, in San Fernando, 45.6% strongly agree, 45.0% agree, 6.9% disagree, and 2.5% strongly disagree that ecotourism makes the municipality attractive. The municipal official said that the development of ecotourism has a huge impact on the beautification of the municipality. As observed, the areas around the periphery of the Cantingas

River and Dagubdob Falls are enhanced by putting huts and benches for tourists and local visitors.

In Cajidiocan, 51.7% strongly agree, 46.2% agree, 2.1% disagree, and 0% strongly disagree that ecotourism makes the municipality attractive. The municipal official said that their municipality has attracted many tourists because of its natural beauty. They have developed biking and hiking trails for the tourists to enjoy. Road improvements to ecotourism sites have also been developed and concreted. He added that aside from the environment, their rich heritage, history, culture, and hospitality also made an impact on tourist arrivals.

In Magdiwang, 45.7% agree, 41.5% strongly agree, 9.6% disagree, and 3.2% strongly disagree that ecotourism makes the municipality attractive. The provincial tourism official and the municipal councilor said that with less damage to the environment and its protection from destruction, the island maintains its charm.

3.1.40. Ecotourism projects will develop more in your area

According to the household survey, in San Fernando, 54.4% agree, 34.4% strongly agree, 9.4% disagree, and 1.9% strongly disagree that ecotourism projects will develop more in the municipality. The ABS-CBN Foundation coordinator and municipal official said that ecotourism will develop more projects in the municipality. The Cantingas River has been installed with Zip-line that tourists can enjoy and even featured on GMA travel documentary. There is an annual inspection of the tourist sites. They put trails for the tourist for easy walking on the way to the sites. The researcher actually met the DOT regional director for MIMAROPA, together with various NGOs, which conducted a comprehensive inspection of the whole of Sibuyan Island for tourism development.

In Cajidiocan, 50.3% agree, 46.9% strongly agree, 2.8% disagree, and 0% strongly disagree that ecotourism projects will develop more in the municipality. The municipal official said that indeed, ecotourism will develop more in their municipality. The on-going road and bridge project of the DPWH to Cawa-Cawa Falls amounting to 65 million will surely help the community around the area and is expected to generate small enterprises. He also added the inspection of the Regional Director of DOT will have an impact in development planning and implementation.

In Magdiwang, 56.4% agree, 34.0% strongly agree, 8.5% disagree, and 1.1% strongly disagree that ecotourism projects will develop more in the municipality. The provincial tourism official and the municipal councilor said that more projects will be focused on the island with the support of various government agencies specifically the Department of Tourism which is keen on developing ecotourism in the area.

3.1.41. Ecotourism projects will run for a long period of time

According to the household survey, in San Fernando, 57.5% agree, 31.9% strongly agree, 9.4% disagree, and 1.3% strongly disagree that ecotourism projects will run for a long period of time. The ABS-CBN Foundation coordinator and the municipal officer said that for as long as the Mt. Guiting-Guiting is there as the primary attraction, and the other tourist sites are maintained, protected, and developed, it is likely to run for a long period of time.

In Cajidiocan, 59.4% agree, 32.2% strongly agree, 8.4% disagree, and 0% strongly disagree that ecotourism projects will run for a long period of time. The municipal official said that

ecotourism is a sustainable tool for development in their municipality. He said further that it helps to preserve the natural environment, respect the carrying capacity of each destination, and promote their culture. Ecotourism will boost the livelihood of the locals and enhances their skills.

In Magdiwang, 53.2% agree, 33.0% strongly agree, 11.7% disagree, and 2.1% strongly disagree that ecotourism projects will run for a long period of time. The provincial tourism official and the municipal councilor said that with the proper tourism planning and development, the industry will run for a long period of time.

3.1.42. I would like to work for Tourism

According to the household survey, in San Fernando, 62.5% agree, 18.8% disagree, 16.3% strongly agree, and 2.5% strongly disagree that they would like to work for tourism. The municipal official said that if given a chance, she will work for the industry.

In Cajidiocan, 62.9% agree, 21.0% strongly agree, 12.6% disagree, and 3.5% strongly disagree that they would like to work for tourism. The municipal official said that he has plans to double his work to help the tourism industry in their municipality.

In Magdiwang, 55.3% agree, 22.3% disagree, 19.1% strongly agree, and 3.2% strongly disagree that they would like to work for tourism. The provincial tourism official said that the tourism industry in the province has been so promising that there are limitless possibilities for everyone. Working in the industry could a both honor and sacrifice. The municipal councilor said that working for tourism entails heart and passion, not just skills.

3.1.43. I would like to support Tourism

According to the household survey, in San Fernando, 56.9% strongly agree, 36.3% agree, 5.0% disagree, and 1.9% strongly disagree that they would like to support tourism. The ABS-CBN Foundation coordinator and the municipal official said that they will support tourism for as long as it will help their constituents.

In Cajidiocan, 52.4% strongly agree, 44.8% agree, 1.4% disagree, and 1.4% strongly disagree that they would like to support tourism. The municipal official said that they will support tourism, one hundred per cent.

In Magdiwang, 51.1% strongly agree, 42.6% agree, 5.3% disagree, and 1.1% strongly disagree that they would like to support tourism. The provincial tourism official said that the Provincial Office totally supports the development of Sibuyan as a whole including every town in the planning and development. The municipal councilor said that they will support tourism all the way.

4. SUMMARY AND CONCLUSIONS

The ultimate goal of this study is to ascertain the benefits and disadvantages of ecotourism in the three municipalities of Sibuyan Island in the province of Romblon. The research made an analysis and assessment in the municipalities where the ecotourism site is located to determine the value of ecotourism for the local government units, non-government organizations, and the local communities to provide an insight in the degree of tourism outcome supported by the Social Exchange Theory. The conceptual framework was designed to gauge if ecotourism creates

benefits and disadvantages in the municipality and that if it could be considered as a basis for sustainable development through the use of economic, environmental, and socio-cultural indicators and different methodologies.

SUMMARY

4.1. The success of ecotourism and the interest of the municipalities to be involved in its development

	Cajidiocan	Magdiwang	San Fernando
1. Familiarity with ecotourism operations in the municipality	✓	✓	✓
2. Familiarity with ecotourism destinations in the Municipality	✓	✓	✓
3. Successful ecotourism inside the municipality	✓	✓	✓
4. Ecotourism attracts more tourists	✓	✓	✓
5. Ecotourism makes the Municipality look attractive	✓	✓	✓
6. Tourism will develop more in the municipality	✓	✓	✓
7. Tourism will run for a long period of time	✓	✓	✓
8. Working for tourism	✓	✓	✓
9. Support for tourism	✓	✓	✓

Table 1.2 Summary to distinguish success of tourism and interest of the three municipalities to be involved in its development.

Table shows that Cajidiocan, Magdiwang, and San Fernando recognized tourism as successful in their community and are interested to be involved in its development.

4.2. The positive economic outcome of ecotourism in the three municipalities

	Cajidiocan	Magdiwang	San Fernando
1. Ecotourism generates more business inside the Municipality such as small enterprises	✓	✓	✓
2. Ecotourism provides permanent jobs for the people in the Municipality	✓	✓	✓
3. Ecotourism provides short term jobs for daily workers in construction such as carpentry, plumbers, electrician, painter, etc.	✓	✓	✓
4. Jobs in Ecotourism are more profitable	✓	✓	✓
5. Ecotourism increases family income	✓	✓	✓
6. Ecotourism changed the jobs of the	✓	✓	✓

people from farming/fishing to tourism			
7. The development of Ecotourism increased yield of local products in your Municipality	✓	✓	✓
8. The development of Ecotourism introduced new types of alternative livelihood	✓	✓	✓
9. The development of Ecotourism increased variety of handicrafts and souvenirs sold inside the Municipality	✓	✓	✓
10. The development of Ecotourism increased the number of hotels/ motels/apartelles within the Municipality	✓	✓	×
11. The development of Ecotourism increased the number of restaurants within the Municipality	✓	✓	✓
12. The development of Ecotourism increased the number of other recreational facilities such as swimming pools, etc.	✓	×	×
13. The development of Ecotourism helps the Municipality to have a better road condition	✓	✓	✓
14. The development of Ecotourism helps the Municipality to have a better water supply	✓	✓	✓
15. The development of Ecotourism helps the Municipality to have a better telecommunication facilities	✓	✓	✓

Table 1.3 Summary of the Positive Economic Outcome of Ecotourism

Table shows that ecotourism projects create positive economic outcome to the three municipalities except the absence of accommodation facilities in San Fernando and recreational facilities in Magdiwang and San Fernando.

4.3. The negative economic outcome of ecotourism in the three municipalities

	Cajidiocan	Magdiwang	San Fernando
1. Ecotourism increased traffic jam inside the Municipality	×	×	×
2. Ecotourism increased cost of living in the Municipality	×	×	×
3. Ecotourism makes house rentals expensive	✓	✓	×
4. Ecotourism increased the cost of land inside the Municipality	✓	✓	✓

5. Ecotourism increased the price of locally produced goods	✓	×	✓
6. Ecotourism increased the price of commodities	✓	×	✓

Table 1.4 Summary of the Negative Economic Outcome of Ecotourism

Table shows that ecotourism did not create traffic jam and did not increase the cost of living in the three municipalities. In San Fernando ecotourism did not make house rentals expensive but in the case of Cajidiocan and Magdiwang would tell us the contrary. The cost of land has also increased in the three municipalities. In Magdiwang, ecotourism did not affect or increase the price of local products and commodities but in Cajidiocan and San Fernando would tell us the contrary.

4.4. The positive environmental outcome of ecotourism in the three municipalities

	Cajidiocan	Magdiwang	San Fernando
1. Ecotourism helps the Municipality to be aware of the importance of their natural environment	✓	✓	✓
2. Ecotourism helps the Municipality to preserve and protect their natural environment	✓	✓	✓

Table 1.5 Summary of the Positive Environmental Outcome of Ecotourism

Table shows that ecotourism creates positive environmental outcome in the three municipalities.

4.5. The negative environmental outcome of ecotourism in the three municipalities

	Cajidiocan	Magdiwang	San Fernando
1. Ecotourism increased air pollution in the Municipality	×	×	×
2. Ecotourism increased noise inside the Municipality	×	×	×
3. Ecotourism makes the surrounding of the Municipality	×	×	×
4. Ecotourism destroys the natural environment	×	×	×

Table 1.6 Summary of the Negative Environmental Outcome of Ecotourism

Table shows that ecotourism did not create negative environmental outcome in the three municipalities.

4.6. The positive socio-cultural outcome of ecotourism in the three municipalities

	Cajidiocan	Magdiwang	San Fernando
1. Ecotourism opens employment and livelihood for women	✓	✓	✓
2. Ecotourism provides part-time job for	✓	✓	✓

students during weekends and school holidays			
3. Ecotourism helps the Municipality to have a sense of pride for their culture	✓	✓	✓
4. Ecotourism helps the Municipality to preserve and protect their culture	✓	✓	✓
5. Ecotourism increased settlement of people in the Municipality	✓	✓	✓
6. Ecotourism decreases urbanization	✓	✓	✓
7. The development of Ecotourism helps the Municipality to have a better health service	✓	✓	✓

Table 1.7 Summary of the Positive Socio-cultural Outcome of Ecotourism

Table shows that ecotourism creates positive socio-cultural outcome in the three municipalities.

4.7. The negative socio-cultural outcome of ecotourism in the three municipalities

	Cajidiocan	Magdiwang	San Fernando
1. Ecotourism increased crime rate	×	×	×
2. Ecotourism destroys the local custom and culture	×	×	×

Table 1.8 Summary of the Negative Socio-cultural Outcome of Ecotourism

Table shows that ecotourism did not create negative socio-cultural outcome in the three municipalities.

CONCLUSIONS

Ecotourism made a huge difference on the lives of the people of Sibuyan. The economic benefits that are making its way to the poor communities have seen to be an important tool to reduce poverty incidence to many areas. The socio-cultural benefits that made the people aware of the significance of their culture and heritage helped immensely to boost their esteem and have raised a sense of pride for the people. The environmental benefits played a vital role to emphasize the importance of nature as the primary capital of the island. Indeed, it is a low impact, environmentally-sound, and community-driven participatory tourism activity that made a way to promote the conservation of biophysical and cultural diversity, and is paving the way to create socio-economic benefits for the local communities. Furthermore, the encouragement that ecotourism has brought to the communities through its educational nature not just for the visitors but for the locals. This has been a good indicator for the goal of the proposed program and strategy for life-long learning. This manifestation promotes the social well-being of the people by eradicating ignorance or lack of education and basic skills which most researchers and social scientists considered as root cause of poverty or would lead to poverty.

Ecotourism gives positive economic results in Cajidiocan, Magdiwang, and San Fernando in terms of the increase of small enterprises, providing some short term and permanent jobs for the people, profitability, increase of family income, increase of the yield of local products, introduction of alternative livelihoods, increase of the variety of handicrafts and souvenirs, increase or development of accommodation facilities, increase of restaurants, development of roads, water supply, and telecommunication facilities.

Ecotourism also provides positive environmental outcomes in Cajidiocan, Magidiwang, and San Fernando in terms of raising awareness about the importance of their natural environment as their main capital and its preservation and protection against mining and other forms of environmental degradation.

Accordingly, ecotourism creates socio-cultural outcomes in Cajidiocan, Magdiwang, and San Fernando due to the employment and livelihood for women and students as part-timers, sense of pride and protection of their culture, increased settlement of people, decrease in urbanization, and the development of health services.

Additional benefits are the indicators of negative outcomes but the community differs for its actuality.

In Cajidiocan, Magdiwang, and San Fernando ecotourism did not create any economic outcomes such as traffic jams and increased cost of living.

In San Fernando ecotourism did not increase house rentals.

In Magdiwang ecotourism did not increase the price of local goods and commodities.

In Cajidiocan, Magdiwang, and San Fernando ecotourism did not create negative environmental outcome such as air pollution, noise, dirty surroundings, and environmental destruction.

In Cajidiocan, Magdiwang, and San Fernando ecotourism did not create negative socio-cultural outcome such as crimes and destruction of local custom and culture.

In terms of disadvantages brought by ecotourism, the following indicators are concluded:

In Cajidiocan and Magdiwang, ecotourism creates negative economic outcome in terms of increased house rentals. The cost of land also increased in the three municipalities.

In Cajidiocan and San Fernando there is an increase in the price of local goods and commodities.

Social exchange theory implies that the early achievements of ecotourism and the interest of the municipalities to be involved on its development based on their evaluations are seen to be an indicator that the people of Sibuyan are aware about this kind of phenomenon and is pleased with the positive implications.

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Economic analysis of instruments for sustainable management of groundwater in Northern Tunisia

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Abstract

Climate change is projected to exacerbate water scarcity and increase the frequency and intensity of drought spells in Tunisia. The impacts of climate change on Tunisia's irrigation activities could be harmful, and call for the development of methodologies that can support the design of sustainable water management policies. This paper presents a mathematical programming model that is used to evaluate the effects of different water management measures for reducing aquifer depletion in the Cap-Bon region of Tunisia. Three policies have been evaluated: prohibition of groundwater overexploitation, environmental taxation, and seawater desalination. Results indicate that the effects of the alternative water management interventions are different in terms of land use decisions and cost-efficiency. Climate change impacts will increase these differences.

Keywords. Climate change, Groundwater depletion, Mathematical programming, Water economics

Résumé

Le changement climatique devrait aggraver la rareté des ressources en eau et augmenter la fréquence et l'intensité des épisodes de sécheresse en Tunisie. Les impacts du changement climatique sur l'agriculture irriguée en Tunisie pourraient être nuisibles, et font appel à l'élaboration de méthodes qui peuvent soutenir la mise en place de politiques de gestion durable de l'eau. Cet article présente un modèle de programmation mathématique qui se utilise pour évaluer les effets des différentes mesures de gestion de l'eau pour réduire l'épuisement des aquifères dans la région du Cap-Bon en Tunisie. Trois politiques ont été évaluées: interdiction de la surexploitation des eaux souterraines, une taxe environnementale, et le dessalement des eaux de mer. Les résultats indiquent que les effets des mesures proposées sont différents en termes de décisions d'utilisation de la terre et du coût-efficience. Les impacts du changement climatique accentueront ces différences.

Mots clés. Changement climatique, Epuisement des aquifères, Programmation mathématique, Economie de l'eau

1. Introduction

Irrigated agriculture is the main user of water resources in most arid and semiarid regions across the world. Irrigation plays an important role in providing food to population, and sustaining rural livelihoods and ecosystems. The foreseeable impacts of climate change in arid and semiarid regions would likely reduce water availability and increase the occurrence of extreme events such as droughts (IPCC, 2014). Therefore, the sustainable management of irrigation water under climate change will become a more complex and difficult task.

Tunisia is one of the countries in the world least well-endowed with water resources. These resources are scarce and their quality is degraded. Tunisia has become a water stressed country in terms of per capita renewable water resources. The water availability is about 400 m^3 per capita, which is well below the global average of 1000 m^3 per capita (WB, 2014). Water problems in Tunisia are linked to the country's shrinking water supply, and to the exceedingly high and growing water demand, mainly in the agricultural sector (that already uses 85% of total water extractions) (ITES, 2014). With most available surface waters already polluted, groundwater resources are now being heavily overexploited. The challenges posed by unsustainable groundwater use are most notable in Tunisia, with withdrawals significantly exceeding natural recharge. The total number of aquifers in Tunisia is about 273, of which 71 are overexploited with an average rate of 146 percent (TICET, 2009). Groundwater depletion amounts to about 650 Mm^3 per year (ITES, 2014).

Groundwater overexploitation is becoming an important policy issue not only in Tunisia but also at global level. Between 1960 and 2000, global groundwater extractions increased from 310 to 730 km^3 per year with depletion amounting to 150 km^3 (Konikow, 2011). This annual depletion amounts to 50 km^3 in the Indus-Ganges-Brahmaputra region, 24 km^3 in the USA, 13 km^3 in the Tigris-Euphrates region, and 9 km^3 in Northern China.

This paper examines the effects of different policy measures to reduce aquifer depletion under current and future climate conditions in Tunisia. The analysis focuses on an intensive irrigated area in Northeastern Tunisia, the Cap-Bon region. This region is one of the most productive agricultural areas in Tunisia, produces most of country's exported crops, and provides considerable employment opportunities for population. Intensive irrigation activities in this region have caused a substantial increase of groundwater extractions, and consequently depletion of groundwater table along with degradation of its quality.

The sustainability of groundwater-based irrigation in the Cap-Bon region has became a real challenge for water authorities and a major policy objective of recent agricultural development plans in Tunisia (Gaaloul, 2008). In this context, the present paper aims to provide information that can support the design of sustainable groundwater management policies in Tunisia.

The remainder of the paper is organized as follows: Section 2 describes the study area and data sources. The following section presents the modeling framework and scenarios of water management. Section 4 discusses the results. The last section draws conclusions and policy implications.

2. Study area and data sources

The Cap-Bon region is located in Northeastern Tunisia (Figure 1). Its climate is semiarid with an average annual precipitation of 420 mm (INM, 2005). Water used in the region originates from four sources: surface water in local dams, groundwater, treated wastewater, and surface water transfer coming from the Medjerda River in Northern Tunisia. Only surface water and groundwater resources are used for irrigation. However, the reduction of surface water availability for irrigated agriculture to meet the growing demand of competing uses is increasing substantially irrigation pressures on groundwater resources.

At present, irrigation extends over 26,000 ha, which represents 26 percent of the total agricultural area in the region. It contributes with about 35 percent to Tunisia's agricultural production (ITES, 2014). Irrigation uses about 74 Mm^3 of water, of which 54 Mm^3 are groundwater resources from the East Coast aquifer, 8.5 Mm^3 are surface water resources from local dams, and 11.5 Mm^3 are surface water resources coming from the Medjerda water transfer project (DGGREE, 2012).

For the purpose of the present paper, our analysis focuses on a 15 percent (or 3,930 ha) of total irrigated area in the Cap-Bon region due to the availability of data. Data has been collected from several primary and secondary data sources. A survey was conducted during 2011 and 2012 with 150 farmers spread across the study area. The data set includes revenue and costs of crops, crop area by irrigation system, labor use, water use, water sources, and water price by source (Table 1).

The selected irrigated area uses water from two sources: surface water that amounts to 11.2 Mm^3 per year (60% of total water use) coming from both the Medjerda water transfer project and local dams, and groundwater extractions from the East Coast aquifer amounting to 7.4

Mm^3 per year (40% of total water use). Groundwater extractions are well above the natural recharge of the aquifer, estimated to be around 0.24 Mm^3 per year. The intensive pumping for irrigated agriculture in this area has caused considerable water table level drawdown (about 5 m below the sea level), and seawater intrusion (with salinity concentration of water between 5 and 8 g/l) (Chebil et al. 2014).

3. Methodology and scenarios

3.1. Modeling framework

The analysis of the water management measures to reduce aquifer depletion is performed using a mathematical programming model. The model maximizes farmers' profits from irrigation activities, subject to technical and resource constraints. A Leontief production function technology is assumed with fixed input and output prices, where farmers are price takers. The optimization problem is stated as:

$$Max\ \pi = \left[\left(\sum_i (P_i \cdot Y_i - Prodcosts_i) \cdot X_i\right) - P_{sw} \cdot SW - P_{gw} \cdot GW\right] \quad (1)$$

subject to:

$$\sum_i X_i \leq Landavail \quad (2)$$

$$\sum_i W_i \cdot X_i \leq Wateravail \quad (3)$$

$$\sum_i L_i \cdot X_i \leq Laboravail \quad (4)$$

$$X_i \geq 0 \quad (5)$$

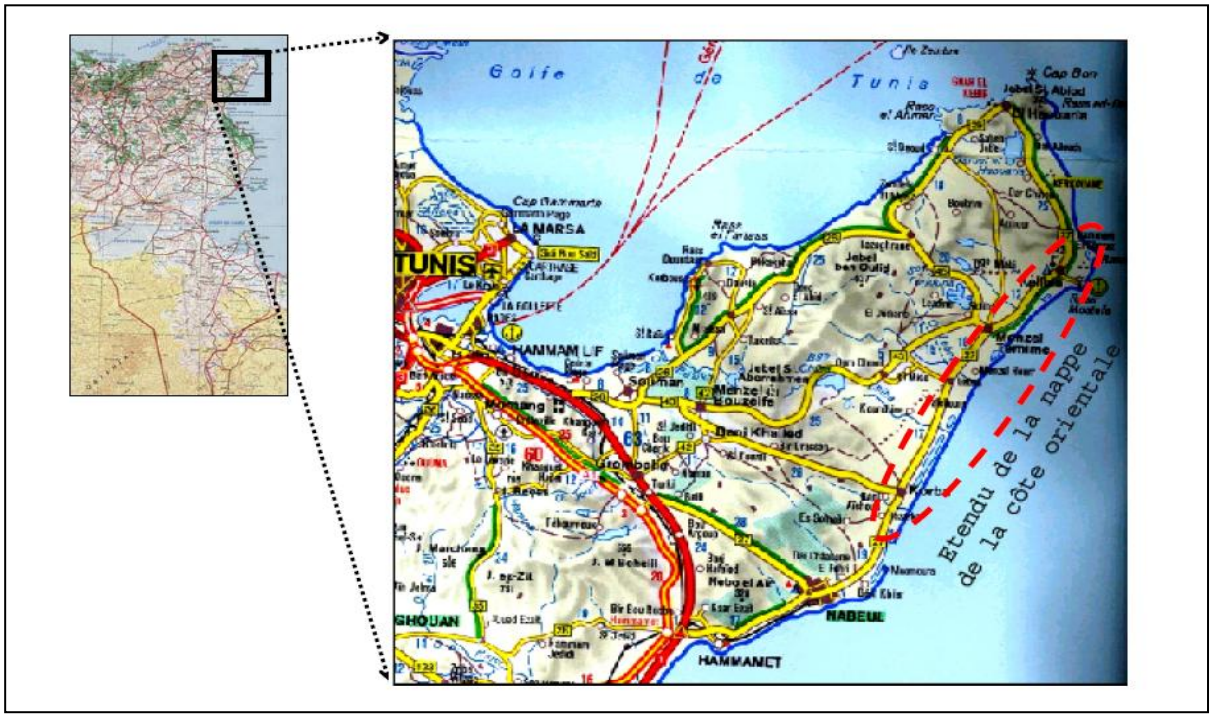

Figure 1. Map of the Cap-Bon region.

Table 1. Crop area, water use and economic data in the study area.

Crops	Land in production (ha)	Water use (m^3/ha)	Labor use (day/ha)	Yield (T/ha)	Crop Price (dt/T)	Revenue (dt/ha)	Cost of production (dt/ha)	Gross margin (dt/ha)
Tomato	865	4,500	109	80	127	10,160	5,079	4,766
Pepper	395	6,745	80	13	500	6,500	4,253	1,775
Strawberry	564	7,841	57	30	1,750	52,500	28,551	23,401
Other summer vegetables	56	4,000	52	30	400	12,000	8,330	3,390
Cabbage	88	3,802	103	70	250	17,500	5,022	12,212
Other winter vegetables	1,166	3,500	58	45,000	0.3	13,500	3,350	9,905
Grenade	144	2,500	23	11	650	7,150	1,297	5,678
Grapes	22	6,000	76	11	1,350	14,850	1,622	12,808
Citrus	72	8,892	27	40	500	20,000	7,254	12,124
Other fruit trees	101	4,500	121	20	650	13,000	4,285	8,400
Fodder	457	3,000	21	350	8	2,800	1,361	1,229
Total	**3,930**							

Note. One Tunisian Dinar (dt) is equivalent to 0.54 US Dollars.

Equation (1) is the objective function of farmers' profits from irrigation activities, which is defined by the difference between crop revenues and costs. The objective function is maximized subject to land use constraint (equation 2), water availability constraint (equation 3), and labor constraint (equation 4). Equation (5) is the non-negativity constraint. The parameters of the model are: P_i=price of crop i; Y_i=yield of crop i; P_{sw}=price of surface water; P_{gw}=cost of groundwater extractions; and $Prodcosts_i$=production costs other than water costs of crop i. $Landavail$ is land available for crop cultivation, $Wateravail$ is the amount of surface and ground waters available for irrigation, and $Laboravail$ is labor availability in the region. The variables of the model are: X_i=area of crop i; SW=surface water use; and GW=groundwater extractions.

The model is calibrated to observed crop area using the positive mathematical programming (PMP) approach. PMP is a methodology developed to calibrate linear programming models using information contained in dual variables of calibration constraints to specify appropriate non-linear objective functions (Howitt, 1995). The application of PMP method as a mean for calibration has significantly increased during the last two decades. The main steps of this method could be found in Howitt (1995).

3.2. Policy and climate scenarios

The mathematical programming model is used to assess the effects of three policy measures under two climate scenarios. The three policy measures are the following:

Policy 1: This measure eliminates aquifer overexploitation, and limits the availability of groundwater resources for irrigation to the natural recharge of the aquifer.

Policy 2: This measure introduces an environmental tax on groundwater extractions in order to reduce extractions up to the natural recharge of the aquifer. This measure is similar to the water pricing policy advocated by the European Water Framework Directive following the "polluter pays" principle.

Policy 3: This measure expands the water supply for irrigated agriculture. The measure aims to substitute non-renewable groundwater resources by subsidized desalinized water. Tunisia has the advantage of having a relatively long coastline which gives it easy access to this resource. Therefore, one potential solution to address the growing water scarcity in Tunisia is to invest in desalinization plants.

The considered climate scenarios are the following:

Scenario 1 or **current climate condition**: This scenario represents the current climate conditions in the study area.

Scenario 2 or **future climate change condition**: This scenario reduces surface water availability by 10 percent and groundwater recharge by 30 percent in 2030.

The selected climate change scenario is in line with the IPCC climate projections by 2030 for the Mediterranean region (IPCC 2014).

4. Results and discussions

4.1. Scenario 1: Current climate condition

In the baseline scenario (without any policy intervention), farmers' profits amount to 32.5 Mdt. The value of agricultural production is 64.3 Mdt. The production costs other than water costs are 29 Mdt and water costs are 3 Mdt. Irrigated area is 3,930 ha. Total water use is about 18 Mm^3 of which 11 Mm^3 are surface water and 7 Mm^3 are groundwater resources (Table 2).

Results of *Policy 1*, that eliminates aquifer overexploitation, and limits the availability of groundwater resources for irrigation to the natural recharge of the aquifer, indicate a reduction of irrigated area by 39 percent, with pepper and fodder removed from the production plan (Figure 2). Water use is reduced by 38 percent. Production costs and water costs are reduced by 30 and 70 percent, respectively. The value of agricultural production falls down by 22 percent from 64 Mdt in the baseline scenario to 50 Mdt under *policy 1*. Farmers' profits decrease by only 5 percent. Labor demand is reduced by 38 percent.

Table 2. Results of the policy measures under current climate conditions.

	Baseline scenario	Policy 1	Policy 2	Policy 3
Crop area (ha)	3,930	2,393	2,393	3,930
Total water use (Mm^3)	18.6	11.4	11.4	18.6
SW use (Mm^3)	11.2	11.2	11.2	11.2
GW use (Mm^3)	7.4	0.24	0.24	0.24
Desalinized water use (Mm^3)	0.0	0.0	0.0	7.2
Value of Agricultural production (Mdt)	64.3	49.6	49.6	64.3
Production costs (Mdt)	28.8	17.8	17.8	28.8
Water costs (Mdt)	3.0	0.9	1.0	3.0
Farmers profits (Mdt)	32.5	30.9	30.7	32.5
Public collection (Mdt)	0.8	0.8	1.0	-5.2
Labor use (days)	266,383	164,874	164,874	266,383

Results of *Policy 2* that introduces an environmental tax on groundwater extractions indicate that the optimal environmental tax that reduces extractions up to the natural recharge of the aquifer is equal to 0.77 dt/m^3. This policy produces almost the same outcomes of *Policy 1* in terms of crop area, water use, value of agricultural production, and labor demand. However, there is a slight decrease of farmers' profits and increase of water costs. In addition, public collection of water fees rise by 24 percent compared to baseline scenario and *Policy 1*.

Results of *Policy 3* that expands the supply of water with subsidized desalinized water indicate that for a full elimination of groundwater depletion in the area, the government should provide a subsidy of 0.83 dt/m^3 (74% of the cost of seawater desalinization). Desalinized water use amounts to 7.2 Mm^3. The outcomes of *Policy 3* are similar to those of the baseline scenario in terms of crop area, total water use, value of agricultural production, production costs, water costs, famers' profits, and labor demand. However, public collection is considerably reduced because of the huge costs of desalinization. Under *Policy 3*, the government spends 5.2 Mdt.

4.2. Scenario 2: Future climate condition

Results of the policy interventions for this climate scenario are shown in table 3. Results of *Policy 1* that eliminates aquifer overexploitation, and limits the availability of groundwater resources for irrigation to the natural recharge of the aquifer show a reduction of crop area by

43 percent, with pepper and fodder removed from the production plan (Figure 3). Water use decreases by 41 percent. Production costs and famers' profits are reduced by 46 and 8 percent,

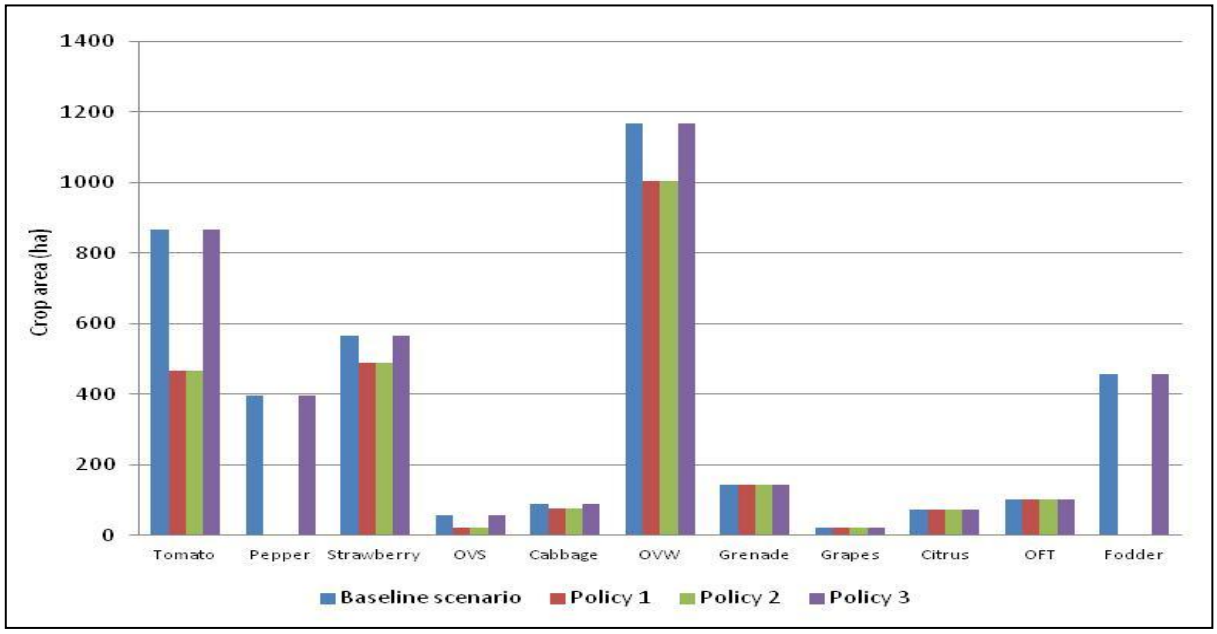

Figure 2. Land use decision for each policy measure under current climate condition (ha).

respectively. The value of agricultural production falls down by 28 percent from 63 Mdt in the baseline scenario to 45 Mdt under *policy 1*. Labor demand is reduced by 44 percent.

Results of *Policy 2*, that introduces an environmental tax on groundwater extractions, indicate that the optimal environmental tax that reduces extractions up to the natural recharge of the aquifer is equal to 1.04 dt/m^3, 35 percent higher than under the current climate condition (or scenario 1). This policy produces almost the same outcomes of *Policy 1* in terms of crop area, water use, value of agricultural production, and labor demand. However, there is a slight decrease of farmers' profits and increase of water costs. In addition, public collection of water fees rise by 26 percent compared to baseline scenario and *Policy 1*.

Results of *Policy 3* that expands the supply of water with subsidized desalinized water indicate that for a full elimination of groundwater depletion in the area, the government should provide a subsidy of 0.83 dt/m^3 (the same amount as under the current climate condition). Desalinized water use amounts to 7.2 Mm^3. The outcomes of *Policy 3* are similar to those of the baseline scenario in terms of crop area, total water use, value of agricultural production, production costs, water costs, famers' profits, and labor demand. However, public

collection is considerably reduced because of the huge costs of desalinization. Under *Policy 3*, the government spends 5.3 Mdt.

Table 3. Results of the policy measures under future climate condition.

	Baseline scenario	Policy 1	Policy 2	Policy 3
Crop area (ha)	3,772	2,134	2,134	3,772
Total water use (Mm^3)	17.5	10.2	10.2	17.5
SW use (Mm^3)	10.0	10.0	10.0	10.0
GW use (Mm^3)	7.4	0.17	0.17	0.17
Desalinized water use (Mm^3)	0.0	0.0	0.0	7.3
Value of Agricultural production (Mdt)	63.4	45.5	45.5	63.4
Production costs (Mdt)	28.2	15.2	15.2	28.2
Water costs (Mdt)	2.9	0.8	0.9	2.9
Farmers profits (Mdt)	32.2	29.6	29.4	32.2
Public collection (Mdt)	0.7	0.7	0.9	-5.3
Labor use (days)	253,836	142,078	142,078	253,836

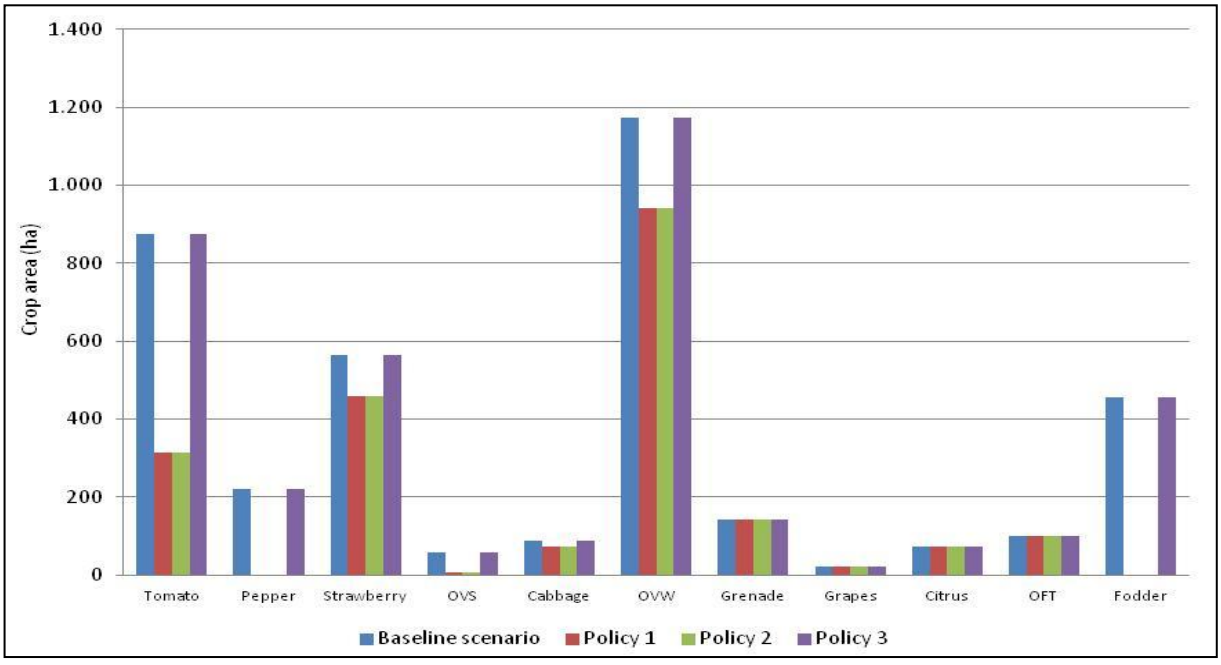

Figure 3. Land use decision for each policy measure under future climate condition (ha).

5. Conclusions

Groundwater depletion is a major environmental issue in Tunisia. Intensive groundwater-based irrigation activities have increased significantly the pressures on aquifers leading to

considerable groundwater table level drawdown, and water and soil quality degradation. Climate change impacts are expected to reduce water availability and increase the frequency and intensity of extreme events in Tunisia. Under these circumstances, water authorities in Tunisia are considering the policies to reduce groundwater depletion without damaging the welfare of irrigation activities under climate change conditions. The choice of these policies requires an evaluation of economic, environmental and social impacts.

This paper aims to contribute to the ongoing policy discussion about the potential policy interventions to reduce groundwater depletion in Tunisia. The paper presents the development of a mathematical programming model and examines various policy intervention alternatives to reduce groundwater depletion under current and future climate conditions. The selected policy intervention alternatives are banning groundwater overexploitation, establishing an environmental tax on groundwater use, and the substitution of overexploited groundwater for desalinized seawater resources.

Results indicate that banning aquifer overexploitation and environmental taxation have significant negative impacts on agricultural production under both climate scenarios by reducing irrigated area and the value of agricultural production. In addition, employment is significantly reduced under those policies. However, farmers' profits are slightly affected. In contrast, the substitution of overexploited groundwater for desalinized seawater resources protects the agricultural production, farmers 'profits, and employment. But the costs for the government are very high compared to the other two policy alternatives.

The mathematical programming model developed in this paper could be improved in the future by including the dynamic aspects of groundwater resources and environmental damages to groundwater-dependent ecosystems. For now, this model provides indicative results to address groundwater depletion in Tunisia and shows the tradeoffs of each policy intervention in economic and social terms.

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Essentials of Rural Poverty: Recommendations to sustainable development

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Abstract
The three pillars of sustainable development are economy, social life and environmental quality. The World countries that adopt sustainable development should take these three dimensions into consideration in their economic development processes. Agriculture is located in the core of these three dimensions because it has important contribution to the economies of less developed countries. Agriculture has social targets. Also, it is the sector which is the most intertwined with environment. Therefore reducing rural poverty is one of the primary policies of countries that target sustainable development. However preventing rural poverty is not an easily applied policy in a globalising world. The negative effects of industrial agriculture, imbalances in the distribution of property in less developed countries, inadequate agricultural support, low level of competition with other sectors are some of the reasons for the failures of policies that aim to reduce rural poverty. Reducing the number of traders on the market, expanding organic agriculture practices, solving the problem of property ownership and levying taxes on large exporter countries and distributing these taxes to countries with low agricultural production and helping them develop their agriculture sector in order for agriculture to become more competitive are some of the measure that can be taken. In this study the reasons of rural poverty and solution proposals are examined.

Key words: less developed countries, poverty, sustainable development, agriculture sector

Introduction
Sustainable development expresses that the future generations are not deprived of social development and environmental quality while current generations carry out their economic development. Poverty exists in the centre of all these concepts. It is impossible to achieve sustainable development together with poverty. In a world where extremely rich or extremely poor countries exist, it is impossible to mention sustainable development. Agricultural sector is at the centre of these arguments. Agriculture as its nature is practiced in countries that are economically strong or weak. Agriculture is important in countries with weak economies in terms of social objectives. In countries with strong economies it is an important foreign trade instrument. Agriculture is also a sector that produces products that are consumed daily in both kinds of countries. It is also a sector that is intertwined with environment. Because of this decreasing rural poverty is one of the top priority policies of countries that target sustainable development. However with the effects of industrialization in agriculture, preventing rural poverty in world economy is not an easily applicable policy. In this research the reasons for rural policy is presented and suggestions are made in the context of agricultural and sustainable development policies.

Essentials of Rural Poverty
Rural areas suggests a part of population that earns their livelihood mostly by agriculture. Agriculture is a production method that requires intensive efforts and that is related to natural conditions. The irregularities in annual income distribution causes lack of new investments. Also the social development of a society that is far away from the possibilities and facilities of the city is slow. Because of this rural areas have social structure that is more closed. Rural population in developed countries are luckier compared to less developed countries. Developed countries that aim to sustain food supply and can use surplus products in foreign trade are in better position to transfer resources to rural areas.

The reasons for rural poverty are based on exogenous and endogenous factors. In the historical process two important endogenous development have been an obstacle in ending rural poverty. Industrial agriculture and globalization. Transition to industrial agriculture has been a very necessary step to end rural poverty et the beginning. With the transition to mechanization world

cereal yield has tripled. However agricultural chemical and machinery usage has increased at the same level. Thus input costs in agriculture also increased (Rocchi et al., 2013).. the transition to industrial agriculture has put developed countries in a difficult position. Organic agriculture has been a starting point for least developed and developing countries. However since organic agribusiness is expensive and the final product being expensive caused the least developed countries to be deprived from these products. Certification process in organic agriculture has left least developed countries and developed countries in a difficult position. Because the obligation to use certified seeds has created additional costs and developed countries with developed agricultural technology have become more advantageous. Since industrial agriculture brought excessive and devastating competition with it, different countries with different development levels have benefited from it at different levels. While globalization has removed the borders between countries and has made foreign trade easier. Developed countries with their management skills and economic infrastructure has caused them to be well ahead in foreign trade. Below graphic shows the shares of developed countries in agriculture foreign trade (Figure 1).

As can be seen in Figure 1, while until 1990s least developed countries' import and export levels were parallel to each other after 1990s the foreign trade balance of aforementioned countries have succumbed to global competition. With the high population increase rates in developing countries agricultural products needs have increased. In order to meet these needs the lands of the developing countries that are insufficient in industry have been bought or rented by multinational companies. Industrialization and globalization requires modernisation in agriculture. However after a point these two important phenomenon started to turn in favour of developed countries. While industrialization is expected to modernize management and business systems as well it has a negative effect on global warming. Industrial agriculture contributes significantly to global warming, representing a large majority of total agriculture-related GHG emissions. Today the benefits that can be gained from industrial agriculture has already been gained, after this point industrialization of agriculture can be expected to bring damages rather than benefits.

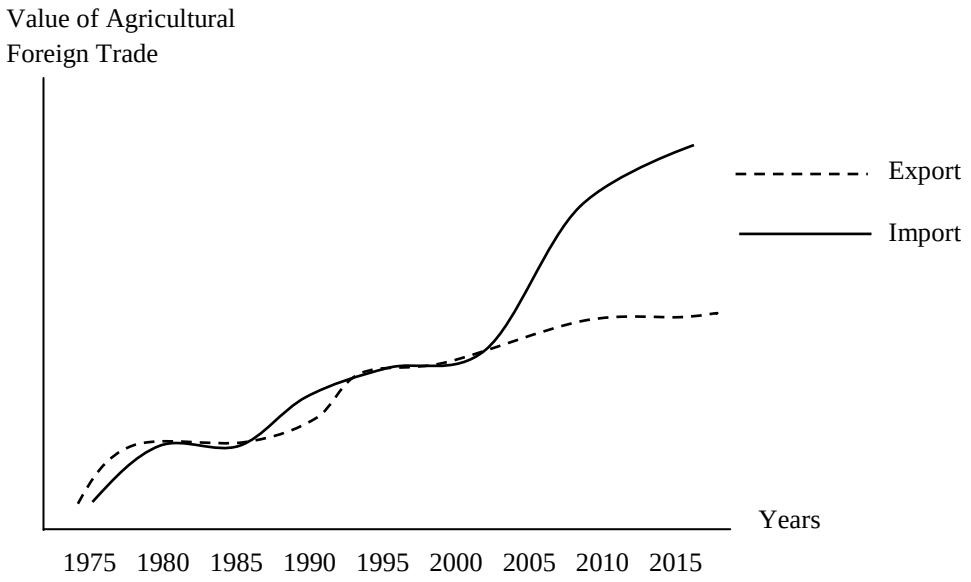

Figure 1. Agricultural Foreign Trade Balance of Less Developed Countries

Case Studies in Selected African Countries and Recommendations

There are many remarkable research surveys carried out in Uganda, Tanzania, Malawi and Kenya regarding with rural poverty. Ellis and Bahiigwa (2003) found important the agricultural levy in the rural settlements. Heavy load on rural people in taddition to agricultural risks create considerable issues in their daily life level. Indeed, whole amount of Uganda's cittizen are living in the rural side. Consequently, taxation system is inevitable phenomenon in this country. Agricultural taxation is still important resource for Uganda's government. Hence, unless urbanization and industrialization is provided in such countries, it is clear that rural poverty is inevitable. Other issues related with poverty are lack of land and livestock as well as inability to secure nonfarm alternatives to diminishing farm opportunuties. Micro level issues of poverty were classified as following: small and declining farm size, lack of livestock as a substitutable assetprevalence of food deficit from own production even in normal years, deteriorating civil security in villages adds to the difficulties of improving household asset status. Mukherjee and Benson (2003) suggested that higher levels of educational attainment, especially for women and the reallocation of household labor away frpm agriculture and into the trade and services sector of the real economy will provide a reduction on poverty in Rural Malawi. Ellis and Mdoe (2003) found some results from Tanzania's rural settlements. The factors of rural poverty are poor schools, health services and rural roads as well as working markets, lack of credit and high costs of farm inputs. Principally, it is really easy to suggest that it is necessary to do more to promote various sectors other than agriculture. Briefly in rural sides, non-farm activities should be developed to combat poverty (Ellis et al., 2003). In addition to micro level interprets, macro level suggestions are related with agricultural sector growth. Pauw and Thurlow (2011) states that Tanzania's weak growth-poverty relationship is also a result of the structure of agricultural growth which has favored larger-scale production of rice, wheat and traditional export crops in specific geographic locations. Indeed accelerating agricultural growth would strengthen the effectiveness of growth at reducing poverty.

Recommendations are clear and as following:

i. Support self-sufficiency capabilities of less-developed countries,

ii.Financial speculative actions should be regulated in global level

iii.Facilitating to be land owner in African countries especially

iv.Organic farming network should be extended, and such productions should be available on the roof of less-developed countries markets

v.Developed countries who want to make agricultural export to less-developed countries should pay a levy to related country in order to distrubute to farmers.

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Geometrical Shape Influence on Energy Harvesting Performance of Oscillating Airfoil

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Abstract:
In recent years, as an alternative to conventional turbomachinery, oscillating airfoils are under increasingly active investigation to extract energy from wind/water. Their potentials for the power generation are studied here numerically. The effect of geometrical shape variation on energy harvesting performance of oscillating airfoil have been investigated. A selective range of parameters have been explored, including the airfoil geometrical parameters: thickness distributions (NACA0012, NACA0015, NACA0018) and trailing edge shapes (sharp, blunt, round); fundamental kinematics parameters, i.e. frequency oscillation ($f^* = 0.10 - 0.20$) at fixed heaving and pitching amplitudes, and the effect of fluid physics (laminar flow, *Re* = 1100 and turbulent flow, *Re* = $5\text{x}10^5$). For the turbulent simulations, the highly resolve numerical simulations ($y^+ \leq 1$) are performed at high pitch angles using the $k - \omega$ SST turbulence model, which is found to model the flow separation effectively. The power-extraction efficiency has been used as the performance comparison metric to be considered in this study. The peak efficiency for laminar and turbulent case has occurred at frequency, $f^* = 0.14$ and $f^* = 0.18$ respectively. Less than 2% differences in power efficiency has been observed on the study of the effect of thickness distribution at low Reynolds number, while more than 10% difference has been found for high Reynolds number by comparing NACA0018 and NACA0012 airfoils. Both laminar and turbulent flows show that sharp edge gives the most optimum efficiency performance, with the highest efficiency for laminar is 33.3% while for turbulent is 44.5%.

Keywords – oscillating airfoil; energy harvesting; laminar and turbulent flow field.

Introduction

Fossil fuel continue to be the major energy resource to the world as compared to renewable resources, (contributing approximately 70%) [1]. However, these resources are known to be of limited stock and the environmental impact of these resources motivate the researchers to develop alternative renewable resources such as; wind, hydro and solar. Hydro resources are the most predictable and economically feasible renewable resource [2]. At present conventional tidal turbomachinery requires a techno-economic flow speed around 2.5 – 3.2 m/s [3], whereby as indicated by [4] technically feasible potential of tidal resource can be twice by lower the operating flow speed to 1.8 m/s.

The mechanical vibration energy resources are based on the flow induced vibration and fluid-structure interaction. One of the technologies that merging this concept is flapping foils or oscillating airfoil system, as they generate spontaneous, self-sustained and large amplitudes vibration that can be couple with the electrical generators to produce electricity [5]. This technology is capable of extracting energy at extremely low airfoil velocities (less than 1 m/s) as compared to rotary turbomachinery. The unique advantages of oscillating airfoils also includes shallow water operation, lower environmental and wildlife impact, small scale power generation and low noise emission [6].

The concept of oscillating airfoils was initially proposed by McKinney and Delaurier [7] in 1981 where they have performed analytical and experimental analyses of flow over a flapping-wing power generator in order to examine its feasibilities. Under applied fluid kinematics parameters of pitch angle of 30° and angle of attack of 15^{o}, McKinney and Delaurier have reported a power efficiency of 17%. Moreover, they showed that unsteady aerodynamics achieve high power efficiency as compared to linear analytical analysis [7]. Later, Kinsey and Dumas [8] carried out computational study to parametrize the influence of fluid kinematic variables on the energy harvesting characteristics of oscillating airfoil systems. The key contribution of his work includes optimization of pitch and heaving amplitudes of oscillating airfoils at particular oscillating frequencies. It was reported that a higher value of power efficiency around 34% can be extracted from the oscillating airfoil at comparatively higher pitch angle of 76.33°. They have also concluded that, leading edge vortices (LEVs) is one of the key parameters to enhanced power generation in flapping airfoil system at low Reynolds number. John Young et. al [9] have also computationally analysed the performance of flow driven flapping wing turbines for wind and water power generation at low Re values of 1100 for prescribed-motion. The research achieved a higher power efficiency value of 30%. At present, the research activities in the fields of oscillating energy harvesting system mainly focused on exploring the highest feasible power generation at low speed and small scale as cited in nature [10] and also to reproduce similar effect in turbulent flow regimes to develop large scale real world applications.

It can be concluded that significant focus is directed towards the investigation of fundamental parameters and the influence on the energy harvesting characteristic of oscillating airfoil such as heaving and pitching amplitude, frequency, phase angle, oscillating motion etc. [11]–[13]. However, the effect of geometry to the power performance is rarely been studied. Therefore, current work comprises the study of the flapping foil geometrical features that includes the effect of thickness distribution, trailing edge shape modification, and a range of frequencies. The numerical simulations in this study are performed with an Eulerian approach and conformal sliding mesh strategy, using the commercial code Ansys Fluent software.

Motion Description

The oscillating airfoil motion in this study has been implemented as combined pitch and heave airfoil motion. Figure 1 shows the imposed heaving and pitching motion at phase angle, $\phi = 90°$. For an oscillating airfoil operating in free stream velocity U_∞, as shown in Figure 2, the combined pitch-heave motion is mathematically expressed as sinusoidal functions [8]:

$$\theta(t) = \theta_0 \sin(\omega t) \quad (1)$$

$$h(t) = H_0 \sin(\omega t + \phi) \quad (2)$$

where H_0 and θ_0 are respectively, the heaving and pitching amplitudes. ω is the angular frequency $(\omega = 2\pi f)$, f is the oscillating frequency and ϕ is the phase angle between the pitching and heave motion.

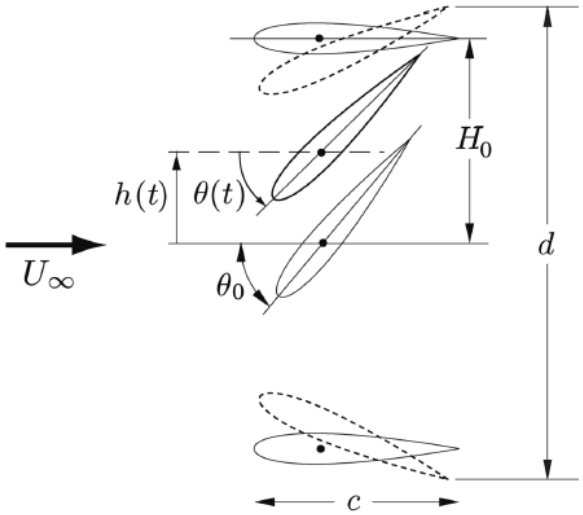

Figure 1: Imposed pitching and heaving motion ($\phi = 90^{\circ}$) [8]

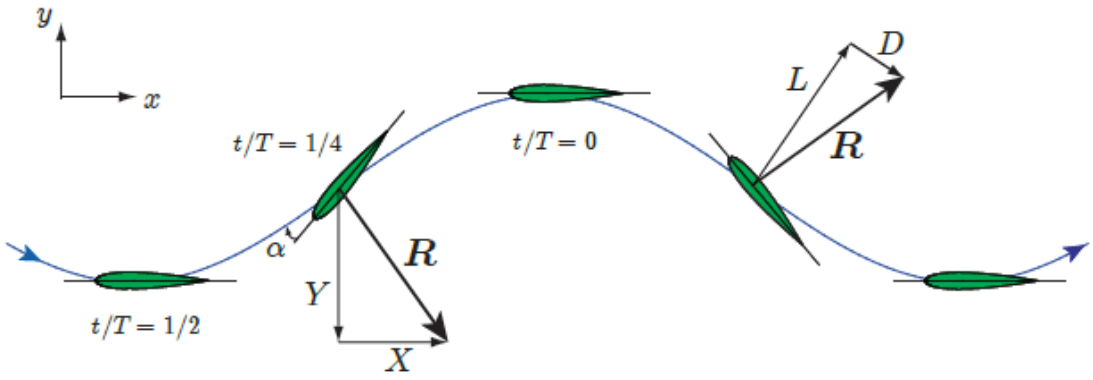

Figure 2: An oscillating airfoil illustrated in a freestream velocity reference frame [8]

Figure 2 shows the resultant aerodynamic force on an airfoil has a vertical component which is in the same direction as the vertical displacement; therefore, the flow performs positive work and power is extracted from the flow because no negative work is involved with respect to horizontal component.

Extracted Power and Efficiency

To quantify the value of extracted power, the time-averaged method is used, where it defines as integrating the instantaneous power extracted in one cycle. The instantaneous power extracted from the flow comes from the sum of a heaving contribution, $P_y(t) = Y(t)dh/dt$ and a pitching contribution, $P_\theta(t) = M(t)d\theta/dt$, where $Y(t)$ is vertical component of aerodynamic force; $M(t)$ is the torque about the pitching axis, x_p. The instance power extraction and the time-averaged extracted power can be expressed as [8]:

$$P(t) = Y(t)\, dh/dt + M(t)\, d\theta/dt \tag{3}$$

$$\acute{P} = 1/T \int_t^{t+T} P\, dt \tag{4}$$

The power coefficient, C_P is defines as the ratio of extracted power P to the total of available power in the free stream. Hence, the mean power coefficient in one cycle can be expressed as [8]:

$$\bar{C_p} = \acute{P}/(0.5\rho U_\infty{}^3 c) \tag{5}$$

Meanwhile, the power extraction efficiency, η is represented as the ratio of the total extracted power to the total incoming flow energy flux within the swept area [8]:

$$\eta = \bar{C_p}\ (c/d) \tag{6}$$

where c and d are the airfoil chord length and the total vertical distance swept by the airfoil leading or trailing edge.

Numerical Methodology

A. Computational Modelling

In all cases presented in this study, the problem is set in a heaving reference frame (vertical translation) attached to the airfoil. The pitching motion of the airfoil motion is rotating in the translating reference frame. This implies the use of time-varying velocity conditions on the inflow domain boundary and the addition of a new source term in the Navier-Stokes equation to account for the reference-frame acceleration. Hence, mesh motion is necessary only for rotating (pitching) motion of the airfoil. This is done by splitting the domain into different zones bounded by a circular conformal sliding interface. The motion of the airfoil is prescribed in ANSYS Fluent V.14.5 through the use of user-defined functions (UDFs) compiled within the solver. The 2D unsteady Navier-Stokes solver flow simulation in this study was modelled as incompressible flow, and the performance behaviour of flapping foils is analyzed for laminar and turbulent flow characteristics.

For laminar flow fields, a second order accurate upwind scheme is used to discretize convection term, and diffusion-term discretization is done with the second-order central-differencing schemes. A second-order backward implicit scheme is used to discretize time. Semi-implicit method for pressure-linked algorithm SIMPLE is used for the velocity-pressure coupling. Gauss-Seidel linear equation solver is used for the discretized equations.

For turbulent flow fields, the turbulence modelling of two-equations $k-\omega$ SST (low-Re correction) has been chosen. Again the SIMPLE algorithm has been selected for pressure-

velocity coupling. Second order schemes are used for pressure, momentum and turbulent viscosity resolution. The unsteady formulation is based on a second order implicit scheme and absolute convergence criteria of 10^{-5} are set for continuity and velocity components while 10^{-4} is used for the turbulent viscosity.

B. Geometrical Modelling

Pointwise commercial mesh software [14] has been used to model the simulation domain and IGES file is the compatible geometrical format required by this package. For this particular requirement, the coordinate data points of NACA profiles has been imported in the SolidWorks CAD modeler. As per scope of the present study, the required geometrical modifications of the trailing edge shape, i.e. sharp, blunt and round edges have been carried out in the SolidWorks environment and then exported the IGES file format into pointwise meshing tool. Three different symmetrical airfoils have been used in this study which are NACA0012, NACA0015 and NACA0018 (Figure 3). All of these airfoils have undergone the same procedure for trailing edge modifications, as shown in Figure 4.

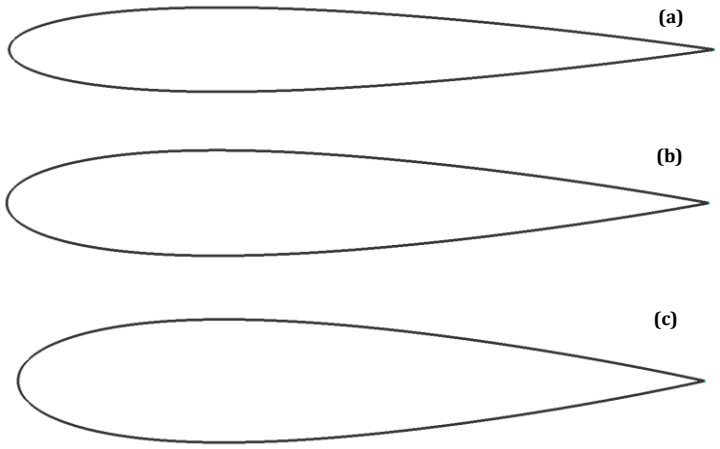

Figure 3: Three different airfoils (a) NACA0012 (b) NACA0015 (c) NACA0018

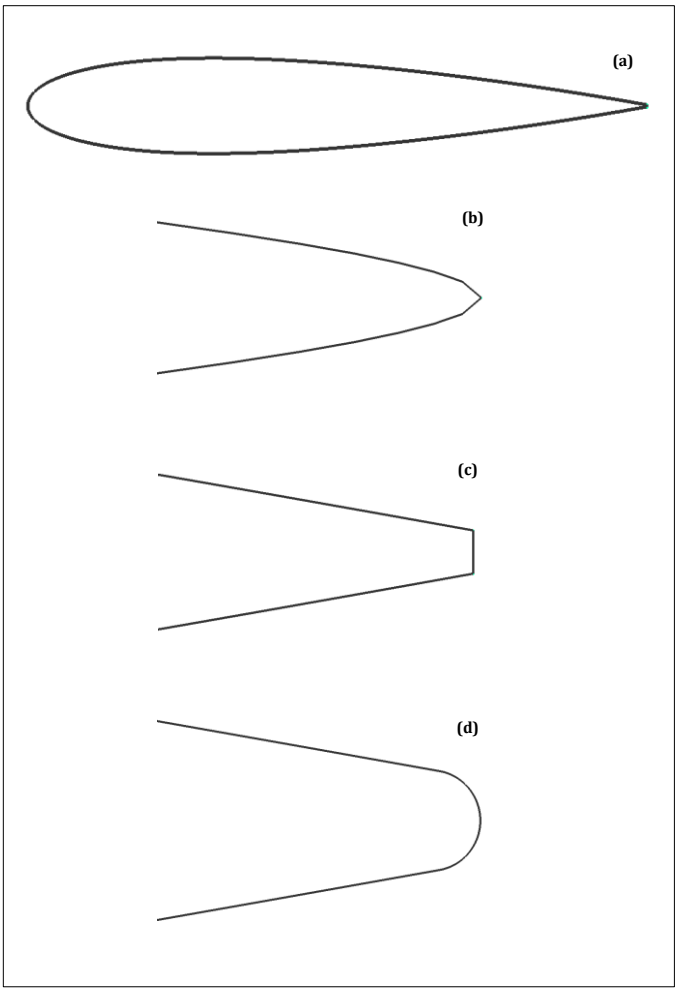

Figure 4: (a) NACA0015 with different trailing edge shapes (b) close-up view of sharp edge (c) close-up view of blunt edge (d) close-up view of round edge

All cases have been simulated using structured grid. The structured grid was developed using O-H topology, as shown in Figure 5(a). The close-up near wall is displayed in Figure 5(c). In this work, a sufficiently large computational domain with reference to the flapping foil chord length '*c*' is used in all of the simulation cases to avoid reverse flow. The upstream inlet velocity boundary and the downstream pressure outlet were located at 35*c* and 40*c* from the pitching point, respectively. The upper and lower flow boundaries were placed at 35*c* from the pitching point.

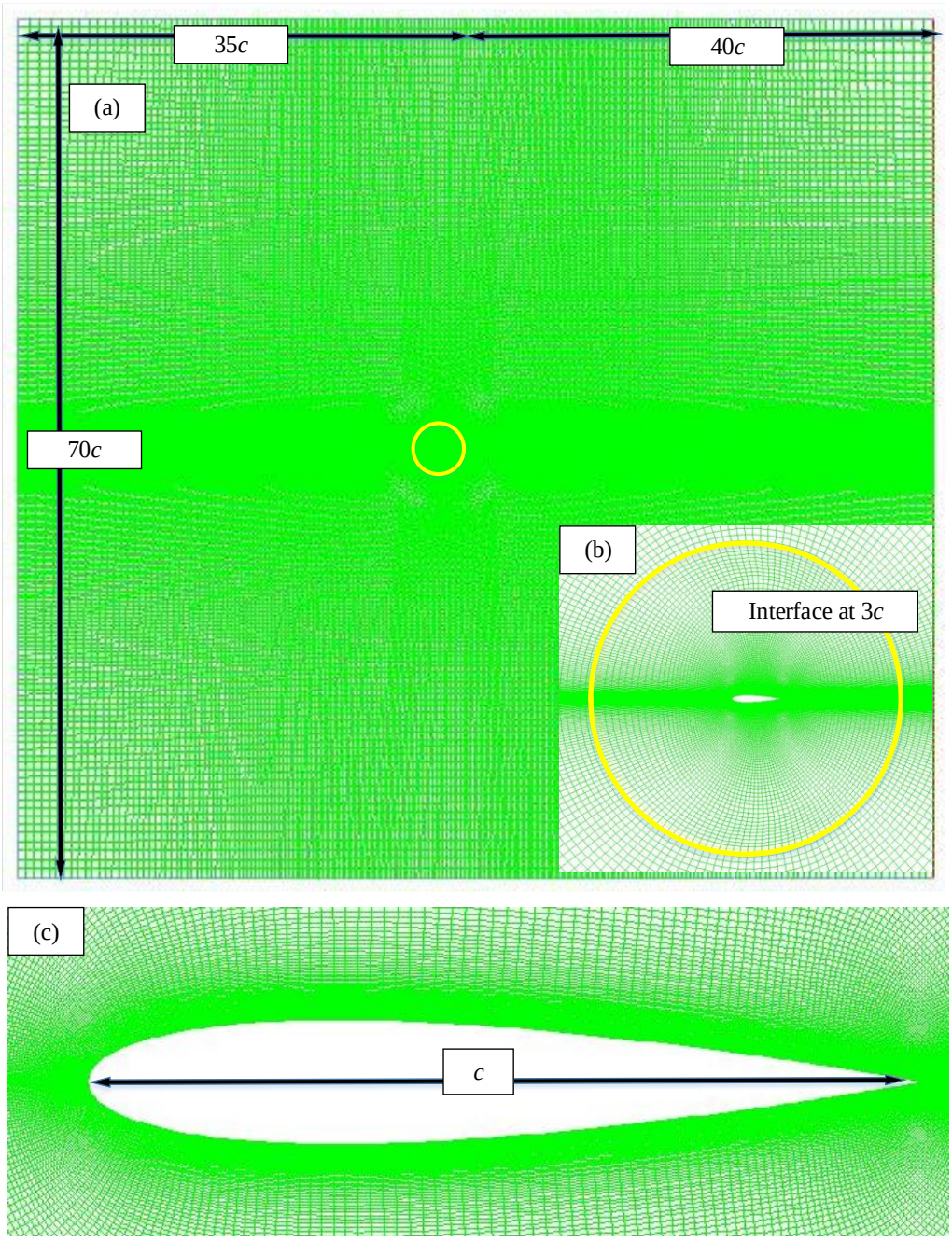

Figure 5: (a) Simulation domain, (b) location of interface, (c) close-up view near wall of the Naca0015

Numerical Validation

Fluid structure interaction study of oscillating airfoils is complex in nature due to aerodynamic behaviour of moving airfoils and resulting large flow separation over the periodic cycle of oscillation. At present there is no experimental data available to validate the implemented design space of geometrical variation of foil system used in this study. CFD based numerical predictions are approximate solutions that require sufficiently refine mesh resolution as a fundamental requirement such that the discretization error is not only small in magnitude but also shows an asymptotic behaviour [18]. In order to have reliable flow parameter predictions, a rigorous 2D mesh sensitivity analysis together with numerical validations of similar airfoil geometry under identical case setup of [8], [15] has been done for laminar and turbulent flow regimes. Due time and computational resource constraints, it is

not feasible to numerically resolve all the instances of parametric design space of geometric and fluid flow parameters. Therefore to carry out this two-step validation process a base line NACA 0015 sharp trailing edge airfoil system is selected.

First of all to optimize the discretization error for both space and time a set of three structured grids are generated following the procedure outlined in the above section (Grid generation) in an order of increasing mesh densities for airfoil surface, rotational and stationery fluid zones. For coarse, medium, and refine mesh the number of computational nodes on the airfoil surface are 150, 300, 500, respectively. The corresponding total cells count of 2D cross sections of simulated domain are shown in Table 1. The simulations are run for sufficiently large number of cycles before the targeted residual values of 10^{-5} for pressure, velocity and turbulence parameters has been achieved. Statistically averaged values of aerodynamic performance coefficients of oscillating airfoil systems, i.e. C_l and C_Y from converged solution have been setup to estimate the mesh resolution and numerical discretization errors. The case setup involves NACA0015 undergoing sinusoidal pitching and heaving motion at Reynolds number of 1100 in order to examine the power extraction performance with parameters setup of $H_0 = 1$, θ_0=76.3°, and $f^* = 0.14$, where the dimensionless frequency is defined as $f^* = fc/U_\infty$. These parameters values were chosen, as they are found to have an optimum performance by Kinsey and Dumas [8].

MESH RESOLUTION	CELLS
Coarse	58,479
Medium	155,010
Refine	300,027

Table 1: Description of mesh sensitivity analysis

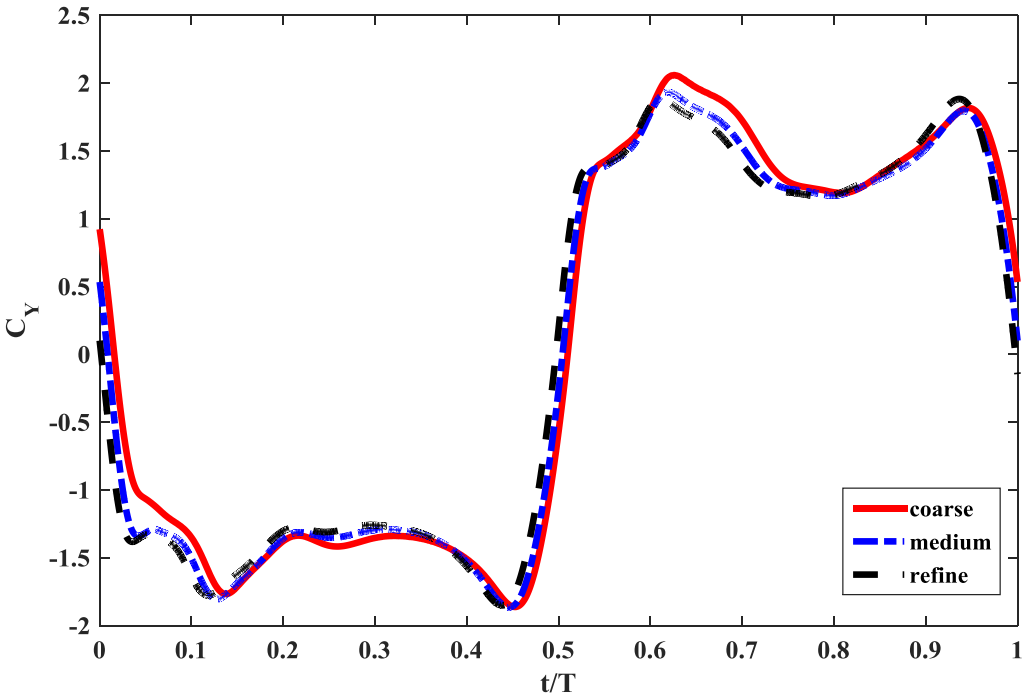

Figure 6: Comparison of performance for coarse, medium and fine mesh

Figure 6 shows the comparison of performance between the coarse, medium and fine mesh. As can be seen, the medium and fine meshes give much closer results. For numerical validation, with the previous published work [8], [15], the medium mesh resolution is selected. Table 2 shows the results for the efficiency, η and power coefficient, $\bar{C}_P$ of the flapping NACA0015 airfoil at Re = 1100, with the corresponding results of Kinsey and Dumas [8]. The results in Table 2 show that our results (present study) compare well with those of Kinsey and Dumas [8]; and the overall differences are less than 5%.

STUDY	EFFICIENCY , η	POWER COEFFICIENT, $\bar{C}_P$
Present	33.3%	0.85
Kinsey & Dumas [8]	33.7%	0.86

Table 2: Parametric study of flows over flapping NACA0015 airfoil at Re = 1100

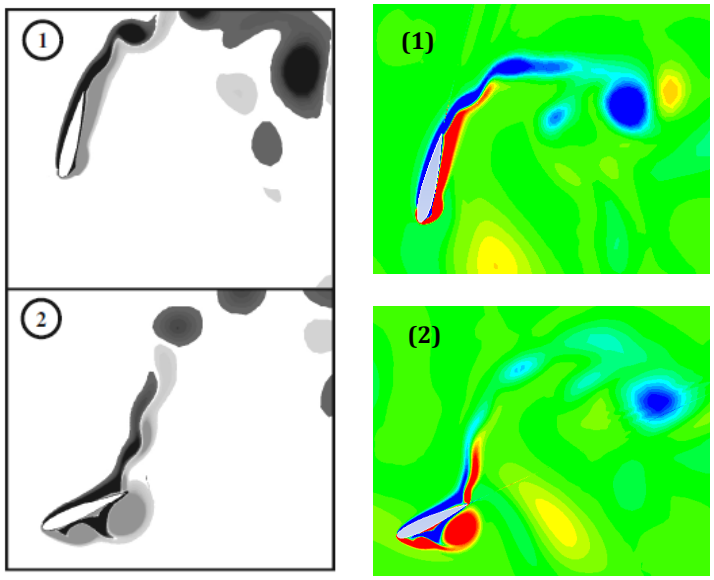

Figure 7: Comparison of vorticity contour of Kinsey and Dumas work (left) and present study (right), (1) at 0.25T, and (2) at 0.45T

Figure 7 shows the vorticity contours of Kinsey and Dumas [8] and the current study (right figures) at 0.25T and 0.45T. These results show similar trends.

In order to further perform the convergence validation, the simulation of imposed pitching-heaving motion of NACA0015 has also been carried out in turbulence flow field at $Re = 5 \times 10^5$, $f* = 0.14$, $\theta_0 = 76.3°$. The turbulence model used is the $k - \omega$ SST with low-Re correction. The turbulent inlet boundary condition for this model has been characterized as an intensity of 0.1% and a turbulent viscosity ratio of 0.01. These stated parameters have been chosen in order to validate the current results with the published work by Kinsey and Dumas [15]. The results were presented in Table 3 and Figure 8.

STUDY	EFFICIENCY , η	POWER COEFFICIENT, $\bar{C}_P$
Present	39.34%	1.0032
Kinsey & Dumas [15]	39.94%	1.018

Table 3: Parametric study of flows over a flapping NACA0015 airfoil at Re = 5 × 105, f^* = 0.14, H_0 = 1, x_p = 1/3

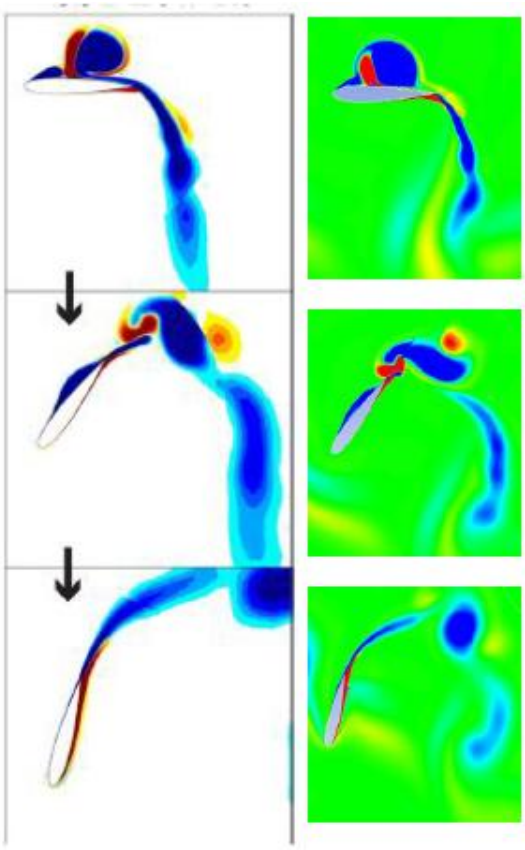

Figure 8: Comparison of vorticity contour of Kinsey and Dumas work (left) and present study (right) at t/T=0, 0.125, and 0.25T

Again, good agreement is achieved in this case. Therefore it can be concluded that the opted numerical methodology is a suitable numerical method for the current investigations.

Results

In this section, numerical findings of the foil system geometrical variation has been discussed. The present data parametrically map the variation in thickness distribution and trailing edge shape. The results for each geometry modification has been compiled distinctly for laminar *Re* = 1100 and turbulent flow (*Re* = 5 x 10^5) while power efficiency of simulated results is compared to explore optimum design configuration. Fluid kinematics parameters such as oscillating frequencies (*f** = 0.10 – 0.20), pitching amplitude, $\theta_0 = 76.3°$ and heaving amplitudes $H_0 = 1$ are held constant for the simulated cases to explicitly identify the effect of geometrical parameters in applied fluid physics regimes.

A. Effect of Thickness Distribution on Performance Efficiency

Thickness distribution is one of the varied parameter in this study. Here, three different NACA airfoils, mainly NACA0012, NACA0015 and NACA0018, have been chosen in order to investigate the effect of thickness distribution on power efficiency. Figure 9 shows the performance trends of simulated NACA foils (with a sharp trailing edge shape configuration) over the range of oscillating frequencies and Reynold's number of 1100. These results show that the effects of thickness variation on power efficiency are small. The maximum difference in the peak values of power efficiency occurs at *f**=0.16 showing an overall variation of

around 2%, whereas the peak efficiency value of 33.3% is at f^*=0.14 for NACA0015 sharp edge configuration.

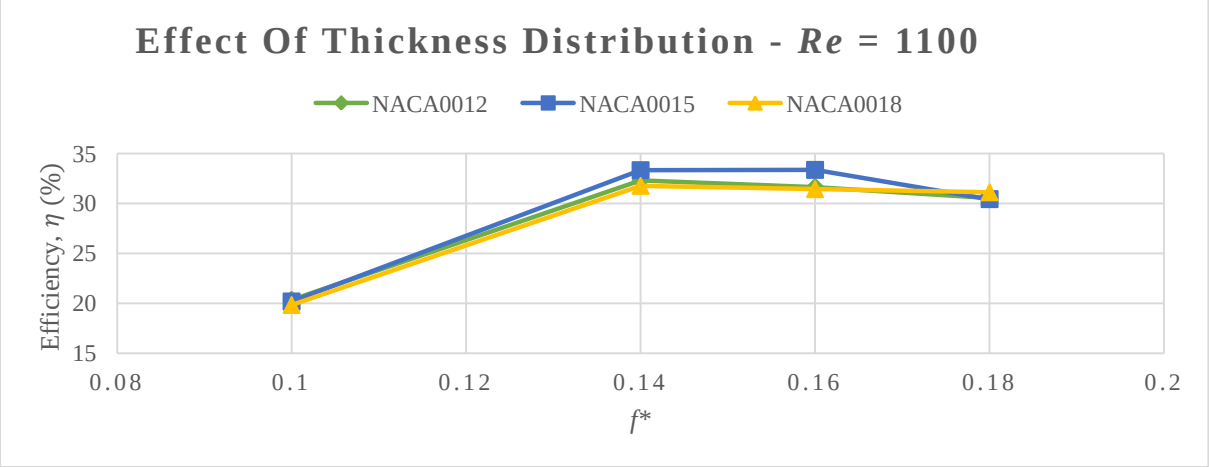

Figure 9: Comparison between NACA0012, NACA0015 and NACA0018 on power extraction efficiency in laminar flow field

Airfoil	Case 1		Case 2		Case 3	
	$f^* = 0.14$	Sharp edge	$f^* = 0.16$	Blunt edge	$f^* = 0.20$	Round edge
	$\bar{C}_P$	η	$\bar{C}_P$	η	$\bar{C}_P$	η
NACA0012	0.82	32.3%	0.72	28.4%	0.60	23.6%
NACA0015	0.85	33.3%	0.71	27.7%	0.62	24.2%
NACA0018	0.80	31.4%	0.75	29.3%	0.57	22.2%

Table 4: Effect of airfoil thickness for selected trailing edge shape; *Re* = 1100

Further analysis on the effect of thickness distribution in laminar flow field has been carried by repeating the procedure at distinct trailing edge shapes. Selective iterations of simulated configurations have been compiled in Table 4. Case 2 demonstrates the effect of thickness variation on power performance subject to blunt edge truncation and oscillating frequency of 0.16. It highlights that the performance efficiency variation is of the similar magnitude, around 2%; similar to Case 1 and Case 3 featuring sharp and round edge truncations and operating at frequencies, f^* 0.14 and 0.20 respectively. Therefore it can be concluded that efficiency is mostly insensitive to the thickness distribution at low Reynold number (laminar flow field).

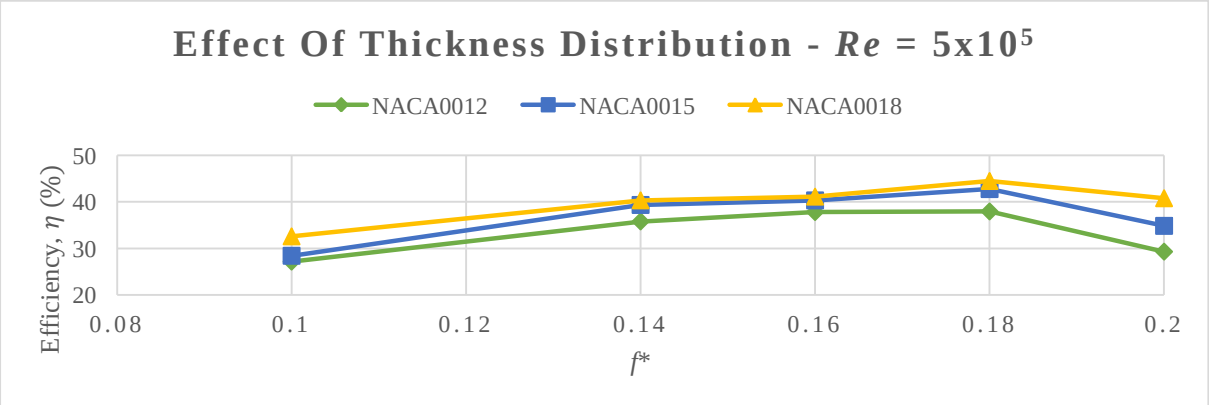

Figure 10: Comparison between NACA0012, NACA0015 and NACA0018 on power extraction efficiency in turbulent flow field

Subsequently the effect of thickness distribution at high Reynolds number has been investigated in this section. In standard trailing edge configuration the data presented in Figure 10 indicates the following trends: over the simulated range of frequencies the increase in thickness distribution results in higher power efficiency values. The thicker airfoil geometries steadily generate higher efficiency values as compared to the thinner foils, as it can be seen that NACA0018 shows a consistent higher efficiency values as compared to NACA0015 and likewise the NACA0015 as compared to NACA0012. The peak value of 44.49% for efficiency is obtained at$f^* = 0.18$ for the NACA0018, showing an increase of 6.5% as compared to NACA0012.

In the design space range of f^* it has been observed that the thinner airfoil geometries show higher gradients as compared to thicker airfoils before and after the peak efficiency values, as shown in Figure 10. The difference in performance efficiency continues to increase over the frequency range. It shows that at oscillating frequency, f^* = 0.16, 0.18 (peak efficiency value, Figure 10) and 0.20, the difference in performance efficiency is 2.5%, 6.5% and 11.5%, respectively between NACA0012 and NACA0018.

Airfoil	Case 1		Case 2		Case 3	
	$f^* = 0.16$	Sharp edge	$f^* = 0.18$	Blunt edge	$f^* = 0.20$	Round edge
	$\bar{C}_P$	η	$\bar{C}_P$	η	$\bar{C}_P$	η
Naca0012	0.96	37.8%	0.82	32.1%	0.46	18.2%
Naca0015	1.03	40.3%	0.90	35.2%	0.73	28.5%
Naca0018	1.05	41.1%	0.99	38.9%	0.89	34.8%

Table 5: Effect of airfoil thickness for selected trailing edge shape; *Re* = 5 x 10^5

Table 5 shows the effect of airfoil thicknesses for different trailing edge shapes and frequencies. From this table, it can be seen that there is about 16% efficiency difference between NACA0012 and NACA0018 by having a round trailing edge at frequency of 0.20. Moreover, it is found that the increase in thickness distribution in case of blunt and round trailing edge configurations has positive impact on the performance efficiency. Therefore it can be concluded that, at high Reynolds number (or in turbulent flow field) thickness distribution does have a positive impact on the power performance with the thicker airfoil.

B. Effect of Trailing Edge Shape on Performance Efficiency

In order to increase the yield of oscillating energy harvesting systems, optimum geometrical combination of thickness distribution and trailing edge shapes are searched in specific fluid flow conditions. Therefore in this section, following the conclusion from the above section (effect of thickness distribution on performance efficiency) that thicker airfoil has a more positive impact on the power performance at high Reynolds number, here NACA0015 and NACA0018 airfoils have been chosen for laminar and turbulent flows in order to further investigate over the design space range of frequencies and trailing edge configurations.

Figure 11 presents the effect of trailing edge modification on energy extraction characteristics of laminar flow, NACA0015 over range of oscillating frequencies. The peak efficiency value is achieved at frequency, $f^* = 0.14$. The data shown in Figure 11 highlights that sharp trailing configuration with peak efficiency value of 33.3% show approximately 7% higher values as compared to the least efficient blunt trailing edge configuration, which is approximately 26.4% efficiency. Similar performance behaviour is seen at higher off peak

values. Therefore it can be concluded that the sharp trailing edge configuration is optimum for laminar flow field and NACA0015.

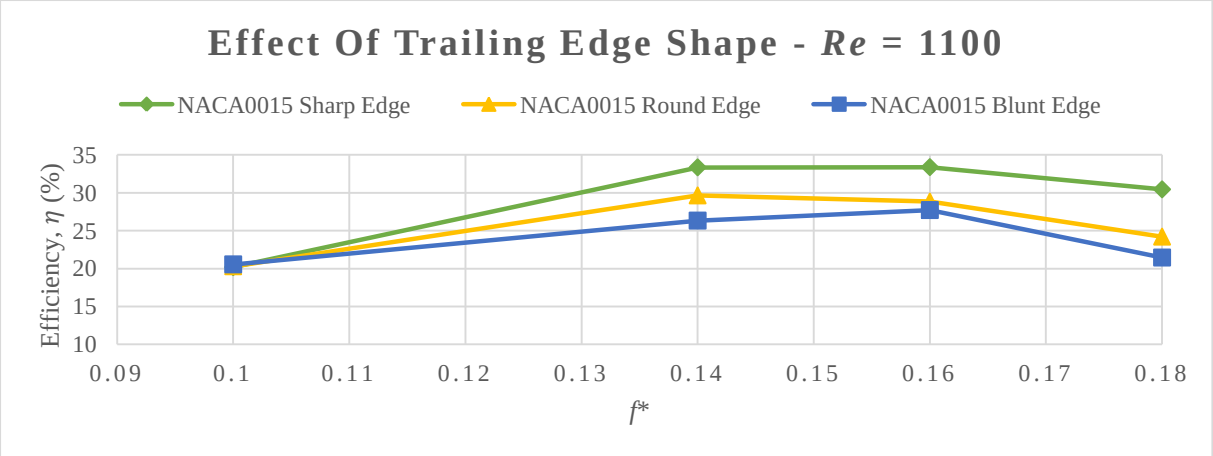

Figure 11: Comparison between sharp, round and blunt trailing edge shape for NACA0015

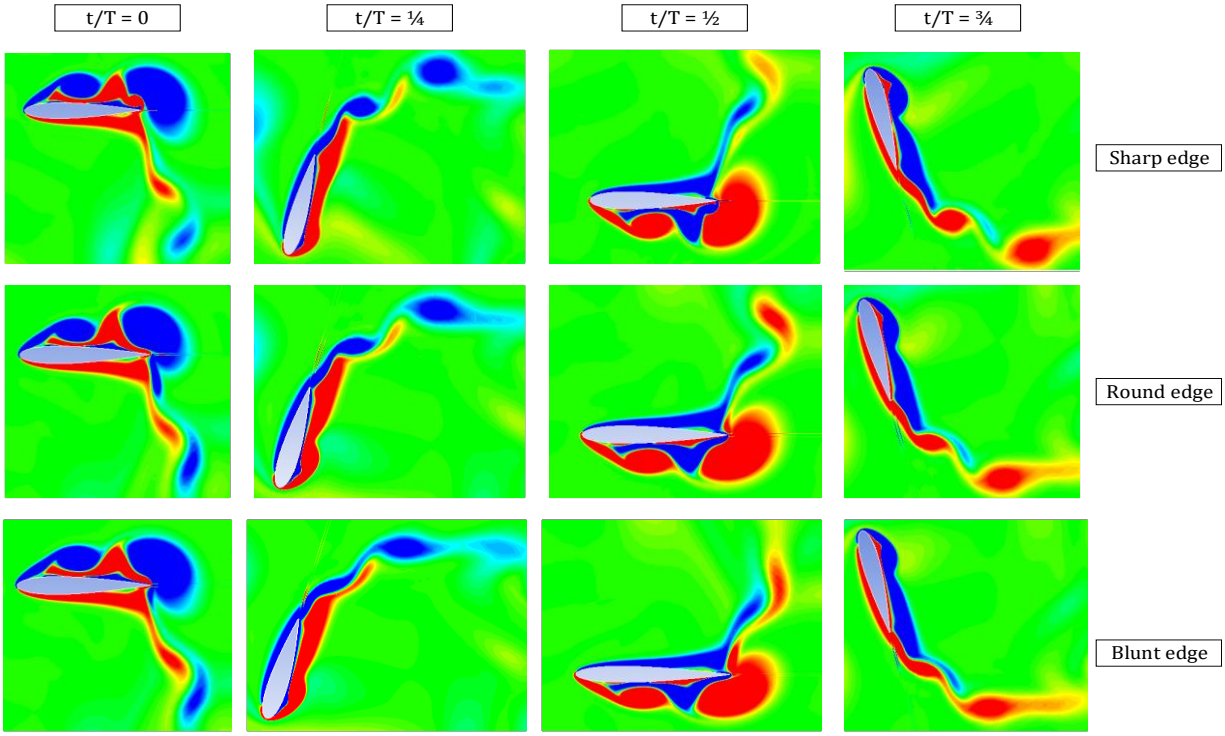

Figure 12: Vorticity fields (red: counter clockwise vorticity, blue: clockwise vorticity) for NACA0015, f^*= 0.14, *Re* =1100 at sharp, round and blunt trailing edge shape

Figure 12 shows the variation in vorticity strength between sharp, round and blunt edges. It can be seen that the vorticity influence is limited to the near wake and trailing edge region. This is due to the differences at the trailing edge shape which is less than 1% difference from the whole geometry.

For turbulence flow field analysis, the optimum airfoil geometry NACA0018 is further investigated for trailing edge shape variation and the power efficiency trends are shown in Figure 13. The sharp trailing edge shape still shows the best performance at each frequency tested. For all three trailing edge shapes that have been tested, the peak efficiency was reached at the oscillating frequency of 0.18. The corresponding peak efficiency values of

approximately 44.5%, 38.9% and 37.7% are obtained for sharp, blunt and round trailing edge configurations, respectively.

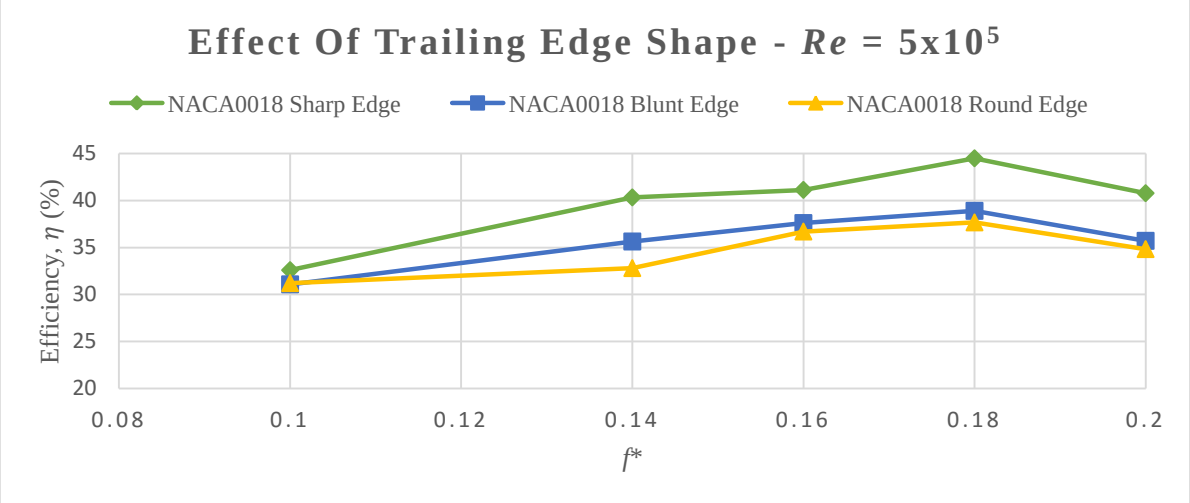

Figure 13: Comparison between sharp, round and blunt trailing edge shape for NACA0018

	NACA0012		NACA0015		NACA0018	
	$\bar{C}_P$	η	$\bar{C}_P$	η	$\bar{C}_P$	η
Sharp	0.9677	37.95%	1.0901	42.75%	1.1344	44.49%
Blunt	0.8195	32.14%	0.8987	35.24%	0.9918	38.90%
Round	0.7826	30.69%	0.8097	31.75%	0.9606	37.67%

Table 6: Parametric study of flows over different trailing edge shape and different thickness distribution

Table 6 shows a comparison of power efficiency and the mean power coefficient at various trailing edge shapes at the optimum frequency ($f^* = 0.18$), for NACA0012, NACA0015 and NACA0018. The data for NACA0012 and NACA0015 show a similar trend as in case of NACA0018. For NACA0012 and NACA0015, the sharp trailing edge shows the highest efficiency value followed by the blunt and round trailing edges, respectively. About 7% difference in power efficiency has been observed between sharp and round edges for NACA0012 and NACA0018 airfoils, while about 11% changes have occurred between sharp and round trailing edges for NACA0015.

Figure 14 shows the vorticity contour for the full cycle of NACA0018 having sharp trailing edge. It show the flow structure around the airfoil at frequency 0.18 for the whole cycle.

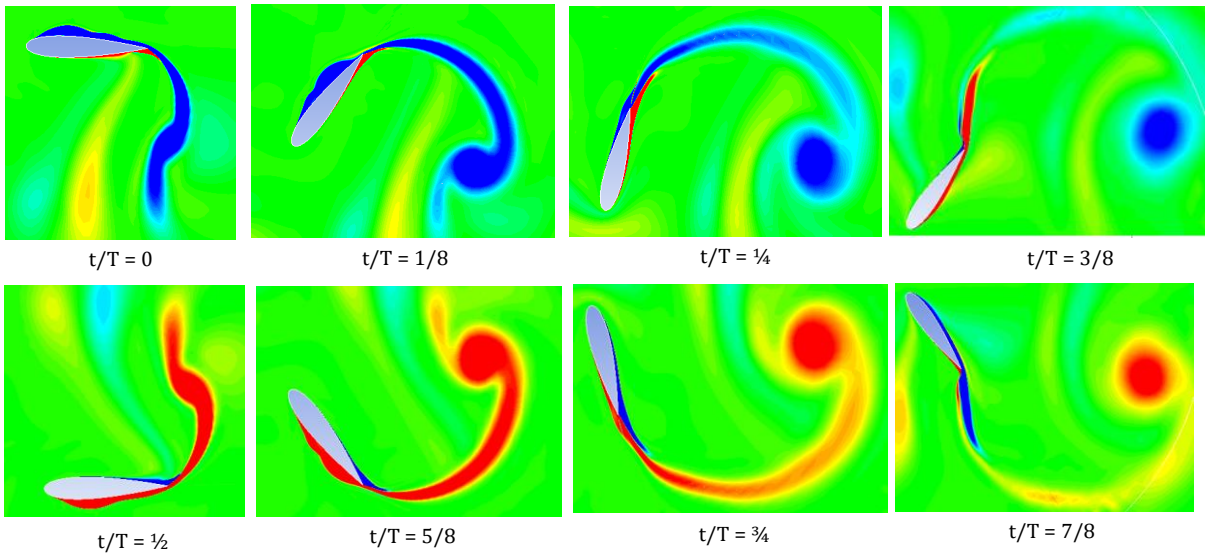

Figure 14: Vorticity fields (red: counter clockwise vorticity, blue: clockwise vorticity) for the entire cycle for NACA0018 having sharp trailing edge shape at *Re* = 5x10^5, *f**=0.18.

Conclusion

In this study, numerical simulations of oscillating airfoils with different geometrical shapes have been carried for power extraction. Simulations have been run in laminar and turbulent flow field on symmetric NACA profile having different thicknesses distribution of 12%, 15% and 18%, and different trailing edge shapes variation (sharp, blunt and round edges). This study have been simulated at the range of frequency, $f^* = 0.10 - 0.20$, and at fixed heaving and pitching amplitudes, and has mainly focussed on the performance of power generation over the entire cycle.

It has been concluded that for the applied conditions of system shape and fluid kinematics, the effect of fluid physics at higher Reynolds numbers has shown higher efficiency values. Moreover, it has been observed that the geometry modifications have significant influence on the performance, and more specifically the trailing edge shape, as compared to thickness distribution. Under turbulent flow field, the results indicates that thickness distribution improves the efficiency performance by having a thick airfoil geometry. About 11.5% efficiency improvement has been observed between NACA0018 and NACA0012 at f^* = 0.20. However, simulation at laminar flow does not show a significant difference when thickness is changed, which is found to be less than 2% difference over the range of tested frequency.

This study shows that the geometrical modification at the trailing edge shape does have an effect on the power efficiency. The sharp trailing edge configuration has indicated highest power efficiency values in both laminar and turbulent flow regimes, with 33.3% and 44.5%, respectively. Moreover, it has been found that the optimal power efficiency is achieved at comparatively low frequency value of $f^* = 0.14$ for laminar and $f^* = 0.18$ for turbulent flow.

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Globalization and Language Learning in a Tourist Destination in Cambodia: Role of Foreign Languages Other Than English in Local Linguistic Ecology

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Abstract

As the world economy becomes globalized, English language is often considered as the main global language in many East Asian Countries. Most developing countries are following a tendency to put emphasis on English to raise foreign capital for development. In Cambodia, French was used as the main foreign language, after its independence from France in 1953. However, according to Clayton (2008), Cambodian curriculums provided secondary students two language choices, English, or French, and a significant percentage of students choose to study English recently. Moreover, the importance of English for economic success has been emphasized in certain studies conducted in Cambodia (e.g., Morrow, 2014). However, these studies lacked consideration for the diversity of local linguistic ecology. The present study took a critical view of previous research insisting on the significance of English in linguistically diverse areas of Cambodia, and investigated the role of learning foreign languages other than English under linguistically diverse local conditions. The current research was conducted in Siem Reap, which is a major tourist destination visited by people speaking different languages. The authors conducted Episodic Interview (e.g., Frick, 2000), by interviewing nine university students that were learning Chinese, Japanese, and Korean. Results indicated that many university students were motivated to learn English for economic and social reasons, whereas they were motivated to learn East Asian languages for cultural and personal reasons. Moreover, a process in which students become interested in foreign languages for their intrinsic value, or become interested in the cultures of those language speaking countries was also identified, which suggested that the purpose of language learning is not only economic, but also intercultural. It is concluded that learning East Asian languages has a significant meaning for university students in Cambodia, which includes developing new attitudes about foreign people appearing among them.

Keywords

Foreign language learning, Diversity, Tourist destination, Local linguistic ecology, Cambodia

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GREEN TECHNOLOGY KNOWLEDGE-BASED AWARENESS LEVEL ASSESSMENT: A BASELINE APPROACH TO DEVELOP MUNICIPAL ENVIRONMENTAL POLICIES AND PRACTICES

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DR. APRIL AURA ANDONG CACHO, MS. JAYE VICENTE ANDONG, and
DR. WILFREDA G. ARONES

Abstract

This quantitative research investigation assessed the knowledge-based awareness level of the 150 respondents in the Municipality of Lemery, Province of Iloilo on the existence of the green technology. The respondents were classified as to government employees, unemployed households, and students. The selection of respondents was determined using purposive convenient sampling. Results showed that out of the 151 respondents, 31.12% were government employees, 23.18% were households and 45.70% were students. The knowledge-based awareness level of the government employees were considered to have been exposed to green technology "oftentimes", however, non-working respondents/households and students had been "seldom" exposed to green technologies. In terms of their feelings towards green technology, government employees were found out to have a "better" feeling towards green technology, while unemployed respondents had a "much worse" feeling and the students were considered to have a "worse" feeling towards green technology. When in terms of their concern level, government employees were "very concerned", unemployed respondents were "not concerned" while students were "somewhat concerned". However, all respondents were perceived to "agree" on the activities about green technology and in terms of their action towards green technology both government employees and students had a "fairly effective" actions while unemployed respondents had a " not effective" action. In terms of interest level, all respondents are considered to be "quite interested" to green technology. Hence, the municipal local government through a strategic discussion among policy makers, establish a policy entitled, "Green Technology Program Service Provider (GTPSP concept) and develop or create best practices on the promotion of the green technology.

Keywords: Green Technology, knowledge-based, awareness, policy, practices

Introduction

The term "technology" refers to the application of knowledge for practical purposes. The field of "green technology" encompasses a continuously evolving group of methods and materials, from techniques for generating energy to non-toxic cleaning products. The present expectation is that this field will bring innovation and changes in daily life of similar magnitude to the "information technology" explosion over the last two decades. In these early stages, it is impossible to predict what "green technology" may eventually encompass. The goals that inform developments in this rapidly growing field include sustainability, meeting the needs of society in ways that can continue indefinitely into the future without damaging or depleting natural resources. In short, meeting present needs without compromising the ability of future generations to meet their own needs. "Cradle to cradle" design, the ending the "cradle to grave" cycle of manufactured products, by creating products that can be fully reclaimed or re-used. Examples of green technology subject areas are energy which perhaps the most urgent issue for green technology, this includes the development of alternative fuels, new means of generating energy and energy efficiency. Green building Green building encompasses everything from the choice of building materials to where a building is located. Environmentally preferred purchasing This government innovation involves the search for products whose contents and methods of production have the smallest possible impact on the environment, and mandates that these be the preferred products for government purchasing. Green chemistry The invention, design and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances. Environmental technology (*envirotech*), green technology (*greentech*) or clean technology (*cleantech*) is the application of one or more of environmental science, green chemistry, environmental monitoring and electronic devices to monitor, model and conserve the natural environment and resources, and to curb the negative impacts of human involvement. Sustainable development is the core of *environmental technologies*. The term *environmental technologies* is also used to describe a class of electronic devices that can promote sustainable management of resources.

In certain municipalities, green technology is not effectively being implemented and practiced by every member of the community. This leads the researcher to investigate whether one is aware or not or has enough knowledge on the so-called green technology. However, as per observation and interview made, there are activities being practiced at home which are much related to green technology however, people are not aware that what they are doing is part of the green technology activities. In this case, a gap or problem was identified on the present activities and the prior knowledge of the community members and these developed a significant point in the conduct of this investigation.

Methodology

This is a quantitative research investigation which measured the knowledge-level of the respondents on the green technology practiced. There were 151 respondents composed of government employees, non-employed community members and students.

Results and Discussion

Table 1 – Distribution of Respondents

Categories	frequency	Percentage
Government Employees	47	31.12
Non-working/Household	35	23.18
Students	69	45.70
Total	151	100.00

Table 2 – Awareness Level towards Green Technology

Category	Exposure		Feeling		Concern		Response		Action		Interest	
	Mean	Description	Mean	Description	Mean	Description	Mean	Description	Mean	Description	Mean	Description
Government Employees	3.4	Often	2.89	Better	4.0	Very Concerned	2.97	Agree	3.09	Fairly Effective	2.0	Quite Interested
Non-working/Household	2.4	Seldom	1.33	Much Worse	1.33	Not Concerned	2.21	Agree	1.45	Not Effective	2.0	Quite Interested
Students	2.2	Seldom	2.89	Worse	2.17	Somewhat Concern	2.90	Agree	3.09	Fairly Effective	2.0	Quite Interested

Discussion:

Based on the above results as presented in Table 2, the government employees were considered to have been exposed to green technology “oftentimes”, however, non-working respondents/households and students had been “seldom” exposed to green technologies.

In terms of their feelings towards green technology, government employees were found out to have a “better” feeling towards green technology, while unemployed respondents had a “much worse” feeling and the students were considered to have a “worse” feeling towards green technology. When in terms of their concern level, government employees were “very concerned”, unemployed respondents were “not concerned” while students were “somewhat concerned”. However, all respondents were perceived to “agree” on the activities about green technology and in terms of their action towards green technology both government employees and students had a “fairly effective” actions while unemployed respondents had a “ not effective” action. In terms of interest level, all respondents are considered to be “quite interested” to green technology.

Conclusion:

On the above results, the following conclusions were made:

1. The government employees are more exposed to green technology than those unemployed respondents and students. This means that they are more knowledgeable and more aware of the concept of green technology.
2. Unemployed respondents and students have a worse feeling towards green technology rather than the government employees because they feel that being exposed to green technology is indeed having more tasks to be done and to be accomplished and green technology is not significant in their daily activities.

3. Employed respondents are considered to be more concerned to green technology not like the unemployed who are not concerned at all and students are somewhat concerned due to the fact that employed respondents knew their civil responsibilities in the environmental care and protection
4. All respondents are positive towards green technology. This means that they favor on the implementation of the green technology in their respective places.
5. The actions or activities being done by the students and employed respondents are described to be fairly effective. This means that they are already doing some activities related to green technology that focus on environmental preservation, protection and care. However, those unemployed respondents considered their action as not effective for they found out that not all of their activities are leading towards environmental care and protection.
6. The interest level of the respondents is described to be "quite interested" in the sense, that their priority is not towards "green technology".

Recommendations:

In order to ensure that green technology be more effectively implemented in the municipality, the following recommendations are forwarded:

1. An awareness program on green technology be conducted to all the members of the community in order to set their minds and concerns on the significance of green technology in their day to day activities. This would also make them realize that some of their activities are also engaged in the so-called green technology.
2. The municipal government together with other sectors of the municipalities particularly in the academe should work hand in hand in the formulation of municipal policies and establish practices that would effectively implement green technology in the municipality.
3. A Green Technology Program Service Provider be established in order to monitor the progress of the implementation of the green technology program in the municipality.

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Groundwater vulnerability to pollution of the Ramsar wetland of Oualidia-Sidi Moussa, Moroccan Atlantic littoral

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Abstract:

The wetland of Oualidia-Sidi Moussa located on the Atlantic coast (32°54'N 008°49'W), is one of the protected sites in Morocco by the Ramsar International Convention. The wetland consists of two lagoons (Oualidia and Sidi Moussa), four swamps, salinas and salt marshes extended on a coastal belt of about 30 km length. The lagoons exchange water with the ocean through narrow inlets. From the inland, the lagoons are principally supplied by groundwater discharging from a karstic aquifer system, making the wetland as a groundwater dependent ecosystem.

Despite its Ramsar status, the wetland faces many threats related to uncontrolled human development and overexploitation of natural resources. The present work aims to contribute to the protection of the wetland by elaborating a vulnerability to pollution map. The vulnerability to pollution addressed in the present study concerns the continental influences on the wetland. Its assessment takes into account the relationship between the wetland of Oualidia-Sidi Moussa and its continental hydrogeological watershed. The groundwater vulnerability map was elaborated using the specific Susceptibility Index (SI) method. The SI is based on the depth to groundwater, the net recharge rate, the aquifer type, the topography, and the land use. The vulnerability map clearly showed that the hydrogeological watershed of the wetland presents generally a low resistance to pollution as it is dominated by medium to high vulnerability to pollution zones. The wetland itself is located in the highest vulnerability zone which is also defined as the highest priority area for land use planning. Analyses of water quality showed that the system is indeed affected by anthropogenic pollution. The preservation of its ecological value requires urgent environmental management actions.

Integrating sustainability triple-bottom-line into a life cycle analysis to evaluate alternative fuel vehicle technologies. From a review of recent development to a conceptual framework for a Malaysian case study

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ABSTRACT

Recently, there has been growing interest in multi-criteria, indicator-based life cycle (LC) analysis tools to facilitate sustainability-oriented decision making within the transportation sector. Despite this development, there is a lack of consistent and standardised approaches for evaluating alternative fuel vehicle technologies in a sustainability context. This paper seeks to review 18 comparative LC analyses of such technologies published in the last five years. The primary aim is to examine the integration of the sustainability triple bottom line (TBL) into the model framework. The review reveals that the existing studies are mostly focused on environmental and/or economic aspects. The social aspect is often excluded from the scope of analysis, thus leaving a lack of balance from the TBL perspective. Nevertheless, the analysis framework is flexible and can be extended to incorporate other indicators according to the TBL dimensions. Next, a conceptual framework for an illustrative Malaysian case study is recommended to provide a coherent and comprehensive assessment of current and near-future technologies. The model developed in the present study is intended to aid transport fleet decision-makers in selecting the 'best option' that achieves the best possible balance across the TBL dimensions.

1. Introduction

Fast-paced and massive urbanisation, particularly in the East Asia-Pacific countries, has raised many challenges for achieving sustainable growth, with issues such as pollution, depletion of natural resources, traffic congestion, and vulnerability to climate change (Bank, 2015, Nations, 2014, OECD, 2014). In light of these issues, alternative fuel vehicle technologies have been given much attention as a way to achieve sustainable transport and green urban development. Green buses and taxis are deployed in many mega cities around the world, such as London and New York, as an initiative to improve air quality in urban areas (Castel-Branco et al., 2015).

In the literature, many publications have reported the performance of alternative fuel vehicle technologies that supports the agenda of sustainable development. Electric vehicles (EVs) were found to produce significantly low carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions during the operational phase, which compensates for the high emissions level during electricity and battery production (see results from (Reuter et al., 2014, Ellingsen et al., 2016, Bauer et al., 2015)). Meanwhile, compressed natural gas (CNG) vehicles provide air quality benefits (Ashnani et al., 2015) and have fewer effects on human health due to lower tailpipe pollutant emissions as compared to the conventional 'oil-based' fuels (Hao et al., 2016, Wadud and Khan, 2013).

Although the deployment of fuel cell buses or taxis has yet to fully materialise, this technology has a significant potential in reducing energy consumption and well-to-wheel (WTW) emission levels (Baptista et al., 2011). As for hybrid vehicles, several studies have concluded that the technology increases energy efficiency and reduces fuel consumption (Onat et al., 2015, Bauer et al., 2015, Gupta et al., 2016, Castel-Branco et al., 2015). Despite the cleaner and more energy-efficient characteristics of these technologies, however, the abovementioned studies do not combine emissions and energy efficiency assessments with cost analyses in the same framework. As a result, the recommended technologies do not necessarily have the best possible balance of economic viability or social and environmental protection.

From an economic standpoint, the abovementioned green technologies were reported to be less cost-effective, particularly due to the high capital cost (Ally and Pryor, 2016, Wang et al., 2015, Lajunen, 2014). In many instances where integration of environmental and economic dimensions is possible, emissions and costs are often conflicting, similarly to costs and energy consumption (see e.g., Ribau et al. (2014), Orsi et al. (2016), Ercan et al. (2015). The use of multiple metrics for evaluating competing technologies makes it even more difficult to compare and determine which option might be the most appropriate with respect to its economic, environmental, and social effects.

Emerging literature has proposed analytical methods for evaluating alternative fuel technologies in a sustainability context. An important consideration to incorporate sustainable development into the decision-support framework is by means of indicators for both quantitative and qualitative measurement (IPCC, 2007). Nevertheless, the indicators used to measure the economic viability, environmental and social burdens of technology options may also vary by region or country, as they cover relevant issues in the local context of sustainable development (United Nations, 2007). Financial incentives, tax exemptions, and fuel subsidies, for example, which differ from country to country, may influence the market

competitiveness of alternative fuel technologies (Lin et al., 2013, Hao et al., 2016, Ong et al., 2012, Streimikiene et al., 2013, Brand et al., 2013).

In recent years, life cycle thinking approaches have been widely accepted in providing valuable support for integrating sustainability TBL into a decision-support framework for product evaluation (Sala et al., 2013, Valdivia et al., 2013, Gundes, 2016). Within the transport and energy sectors, however, the method for conducting integrated assessments is still debatable. More often than not, the assessments carried out in previous studies have differed in terms of the methods, scopes, and system boundaries as well as the criteria for evaluating options. This lack of consensus on a standard approach to properly appraise the selection of alternative fuels/green technologies and the need for integrating the economic, environmental, and social impact assessments has been discussed in the latest publications e.g., Gundes (2016), Santoyo-Castelazo and Azapagic (2014), Onat et al. (2016).

This paper seeks to examine the integration of the TBL into the existing LC analysis framework to quantitatively assess a wide range of alternative fuel technologies in a coherent and standardised manner. Within the transport sector, existing literature on the comparative review of LC models is primarily focused on a particular technology e.g., Von Blottnitz and Curran (2007), Larson (2006), Davis et al. (2009). The originality of this paper is that it reviews recent LC analysis studies either from economic, environmental, or social perspectives across multiple different alternative fuels/vehicle technology options, which has yet to be undertaken. It contributes to fulfilling the gap in recent publications in peer reviewed journals that compare such analyses for private and public transport applications in all parts of the world.

This paper is structured as follows. First, it presents the background and context for undertaking this study (Section 1). Then, Section 2 reviews the goal and scope, system boundary, and LC methods for evaluating options in each of the reviewed case studies. In addition, the dimension of analysis and the use of indicators for evaluating criteria from the sustainability TBL perspective is examined. Next, Section 3 discusses the observation and gaps that need to be addressed. Following this, Section 4 concludes the review and recommends an integrated decision-support framework to undertake a comparative LC analysis for an illustrative real-urban case study, taking into account current and near-future technologies for transport fleet applications.

2. Review of LC Analysis of Alternative Fuel Vehicle Technologies

An examination of the academic literature has uncovered numerous publications that have studied currently available (and future) alternative fuel technologies for private and public transport vehicles from the TBL perspective. Nevertheless, this review is only focused on the quantitative analysis of such technologies, conducted on an LC basis. The literature search was based on a topic search, predominantly through keywords ‘Life cycle analysis’ and ‘alternative fuel vehicle technologies’ in Scopus, Web of Science, and ScienceDirect as well as through Google Scholar, which returned almost 60 publications.

In this paper, only peer reviewed scientific journal articles published within the last five years (2011–2016) are selected. For any study that was published in multiple articles, only one is considered for the review. The next criteria for selection is whether the LC analysis is comparative, evaluating at least three different alternative fuel/technology options. This is to

ensure a wide range of comparison and that the selected studies are not biased in favour of any particular technology.

Table 1 provides an overview of the 18 selected articles, of which five were published in 2016. Since the selection criteria has significantly narrowed down the number of studies, the selected publications do not represent the complete literature on comparative LC analysis of alternative fuel vehicle technologies in real-world applications. However, they are deemed representative of all the reported work that meets the selection criteria.

The review of the studies is structured into the following four main sections:

- the goal and scope definition,
- system boundary (category, length, and stages of the LC period),
- evaluation method, and
- dimension of analysis and indicators.

2.1. The Goal and Scope

Irrespective of the different objectives of the study and the intended applications for conducting the comparative LC analysis, the common goal of an analysis is to determine the best alternative fuel technology, either from a cost, energy consumption, or emission-impact point of view. Meanwhile, the scope definition (outlined in Table 1) varies, which was analysed according to the following features:

a) the geographic context,
b) the type of transport vehicles, and
c) technologies/alternative fuels compared.

From the review, the majority of studies (12/18) are conducted in European and North American contexts. With the exception of a study that cover a total of five countries from Asia and Europe (Orsi et al., 2016) as well as the evaluation different types of city buses in Finland and the USA (Lajunen and Lipman, 2016), all other studies are based on country-specific real data. The abovementioned studies covering multiple countries are intended to analyse different powertrain technologies simulated in different operating environments. Additionally, a comparative analysis is performed to further investigate whether or not there is any fundamental difference in the result and in the fuel pathways due to a specific energy mix of a particular country.

In terms of specific applications, the reviewed studies are fairly distributed between private and public transport vehicles. Among the selected case studies, 10 of the LC analyses are conducted to evaluate different alternative fuel technologies for standard light duty passenger vehicles (LDV), followed by city buses with six studies. The remaining two studies are focused on taxi-specific applications (Reuter et al., 2014, Baptista et al., 2011).

In all the reviewed studies, the comparisons between alternative fuel technologies are made against the conventional petrol or diesel powertrain. In most cases, diesel ICE is used as the reference or benchmark powertrain for comparing technology options for city buses or taxis, whereas petrol ICE is mainly used in the case of LDV. Among the green technologies, electric and hybrid powertrains are evaluated in all the reviewed studies, followed by natural gas vehicles and fuel cell technologies with 11 studies each. Meanwhile, liquefied petroleum gas (LPG) is only covered in one study. Biodiesel is studied in 3 studies whereas other alternative fuels (i.e., bioethanol, methanol) are evaluated in one study.

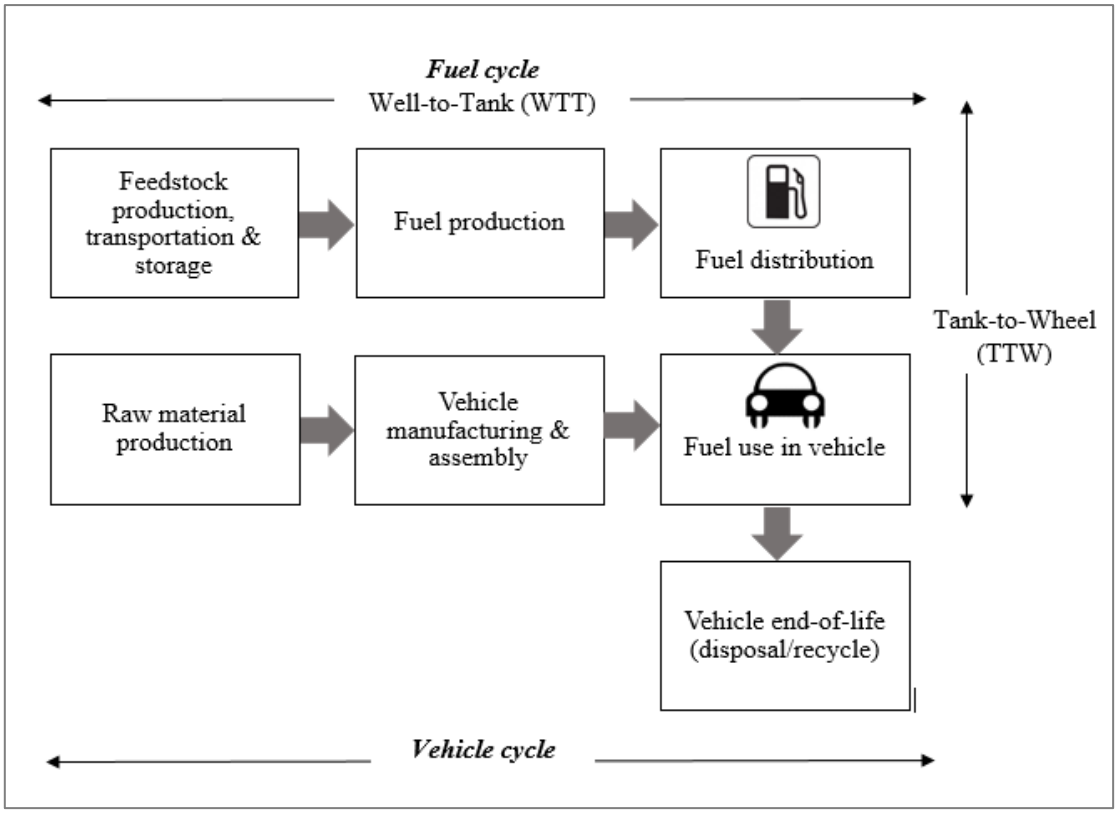
2.2. System Boundaries (Category, Length, and Stages of Life Cycle)

Following the guideline of ISO 14041 standards in defining the goal and scope of the LC analysis as described by Testa et al. (2011), the review examines the category and length of the LC period, and the stages included within the specified system boundaries. Generally, the LC analysis of alternative fuel vehicle technologies is either conducted from the perspective of a fuel or vehicle LC or a combination of both (i.e., 'full life cycle') as shown in Figure 1.

A complete fuel cycle, often known as WTW, consists of two components, 'well-to-tank' (WTT) and 'tank-to-wheel' (TTW). The WTW essentially covers the LC steps from the energy resource extraction stage (fuel production) and goes all the way to the phase in which it is used in the vehicle (vehicle operation), as defined in MacLean and Lave (2003). As for the vehicle cycle, it typically begins with material production required for the manufacturing process *(initial)*, then vehicle operation *(in-use)* and ends when it is recycled or disposed *(end-of-life)* (Gao and Winfield, 2012), often termed 'cradle-to-grave' (CTG). Meanwhile, a study by Bauer et al. (2015) extended beyond the common full LC stated above by adding road infrastructure.

Of the reviewed studies, 11 undertook the LC analysis from a combined perspective, whereas the remaining five and two studies were conducted based on fuel and vehicle cycles, respectively (see Table 1). All five studies based on the fuel cycle covered the WTW, including the analysis conducted by Patil et al. (2016), which reported the results in two parts, starting with TTW results by Gupta et al. (2016). One study that analysed technology options from the vehicle cycle perspective (Ally and Pryor, 2016) is primarily concerned with assessing the economic aspect of technology options during the operation phase, which does not require investigation during the fuel cycle stages. Contrary to this study, however, the analysis conducted by Onat et al. (2016), which was continued from the work of Onat et al. (2014), is focused on covering the vehicle CTG in fulfilling the objectives of the study.

In terms of the length of the LC, most studies cover a period between 10-15 years. However, two studies (Reuter et al., 2014, Messagie et al., 2013) are conducted for a period of less than 10 years. A number of studies do not undertake the analysis based on vehicle useful years, but instead use the lifetime travel distance (Onat et al., 2016, Ribau et al., 2014, Gao and Winfield, 2012, Baptista et al., 2011). Meanwhile, there is neither a life cycle period nor vehicle lifetime distance specified in one of the study (Xu et al., 2015).



Source: Adapted from Gao and Winfield (2012), Ribau et al. (2014)

Figure 1: A typical life cycle of alternative fuel vehicle technologies.

2.3. Life Cycle Evaluation Methods

The LC analysis can be characterised by the method and approach for evaluating options. The two most common LC methods applied in the literature are the LC assessment (LCA) and LC costing (LCC). However, these methods are sometimes substituted with different terms in the current literature. For example, a few studies (Elgowainy et al., 2013, Orsi et al., 2016) use the term WTW analysis for environmental impact assessment, whereas the LC cost analysis is conducted involving total cost of ownership (TCO). Irrespective of the different techniques, all analyses reviewed in this paper are conducted on the LC basis. Therefore, for easier comparison, they are categorised as LC methods (LCA and LCC) in this study.

An environmental LCA is present in the majority of the reviewed studies (12/18), including the hybrid input-output (IO) based method adopted by Ercan and Tatari (2015). Unlike the traditional LCA, this hybrid IO model enables the economic effect to be quantified alongside the energy and emission-impact assessments. This method is particularly useful for bringing cost factors into the decision making, although it involves multiple metrics. For a more advanced method, Onat et al. (2016) developed a novel hybrid LC sustainability assessment (LCSA) model by combining both the process-based and IO model-based LCA. Named TBL-LCA, the model incorporates social and economic indicators and presents an IO-based holistic sustainability accounting framework. Unlike the model developed in Mitropoulos and Prevedouros (2015) that integrates external emission costs with societal and consumer life

cycle costs, the other study applying the LCC model (Ally and Pryor, 2016) is only intended to assess the financial aspects of technology options.

While all the abovementioned studies seem to adopt one particular method, such conclusion cannot be made in the case of four studies (Lajunen and Lipman, 2016, Elgowainy et al., 2013, Nanaki and Koroneos, 2013, Gao and Winfield, 2012). These studies combine both LCA and LCC approaches to evaluate the life cycle emissions and costs of different technologies.

2.4. Dimension of Analysis and Indicators

In essence, the reviewed studies address either the economic, environmental, or social aspects of different alternative fuels/technology options. In this review, the factors are analysed using a set of indicators categorised according to the TBL dimensions as shown in Table 2. It is worth mentioning that it does not represent the complete list of available indicators but only those that are applied in the reviewed studies.

Of the reviewed studies, the single-dimension type of analysis is applied in six studies of which five are focused on the environmental effects from emissions and energy use, whereas the remaining one study is only concerned with the lifetime costs associated with vehicle purchase and operation, plus the end-of-life disposal (Ally and Pryor, 2016). Other cost and benefit factors, particularly taxes, incentives, or subsidies, are also observed. McKenzie and Durango-Cohen (2012), for instance, include fleet purchase subsidies since the hydrogen fuel cell demonstration bus exceeds the competitors by an order of magnitude. Without such subsidy, it has no market competitiveness. Although government taxes are categorised under the social dimension in Onat et al. (2016), this indicator is grouped under the economic dimension in this review.

On a slightly more comprehensive overview, the analysis conducted in 12 of the studies involved indicators from multiple dimensions. The economic-environmental duo is the most adopted combination, with eight studies. In these studies, the measured indicators include LC costs or TCO, GHG/CO_2 emission or global warming potential (GWP), and fuel consumption. Only one study combines social with environmental indicators (Bauer et al., 2015) in valuing climate change and air pollutant-related health effects. In this study, the LC impact assessment extends beyond GWP. Three further environmental indicators (i.e., terrestrial acidification potential from nitrogen oxides and sulphur dioxide emissions, particulate matter formation (PMF), and photochemical oxidant formation (POF) or 'summer smog') are included. The integration with the social dimension is achieved through the assessment of these factors, as they also represent potential effects on human health, in addition to human toxicity potential (HTP) due to emissions of toxic substances, such as heavy metals and hydrocarbons.

From a more holistic sustainability perspective, the integration of TBL is observed in only three studies (Mitropoulos and Prevedouros, 2015, Messagie et al., 2013, Onat et al., 2016). These studies are the only reviewed LC analyses that combined fuel and vehicle-related costs, GWP, and/or pollutants that affect the environment with public health effects from tailpipe emissions. The TBL integration in these studies is of particular interest, as it allows the existing LC analysis model to evolve into a sustainability analysis tool. Onat et al. (2016) has attempted to move toward this integrated approach by assessing alternative vehicle technologies based on the LCSA framework. In this study, which is a continuation from Onat

et al. (2014), 16 macro-level indicators representing the wider context of environmental, economic, and social effects are considered.

Table 1: The scope of the reviewed studies

Year	Author(s) of publication	Geographic context	Type of vehicle	System boundary							LC method/ model	Technologies evaluated/compared								
				Category and length of life cycle (years)[1]		WTT	TTW	Initial	In-use	End-of-life	Other[2]		Petrol ICEV	Diesel ICEV	NGV	LPG	BEV	HEV/PHEV	FCEV/H_2	Biodiesel	Other
2016	Ally and Pryor (2016)	Australia	Bus	Vehicle	15			√	√	√		LCC		√	√			√	√		
	Lajunen and Lipman (2016)	Finland & USA	Bus	Combined	12	√	√	√	√			Combined		√	√		√	√	√		
	Onat et al. (2016)	USA	LDV	Vehicle	N/A			√	√	√		LCA									
	Orsi et al. (2016)	Brazil, China, France, Italy & USA	LDV	Fuel	10	√	√					LCA	√	√	√		√				√
	Patil et al. (2016)	India	LDV	Fuel	10	√	√					LCA	√	√	√	√	√	√			
2015	Bauer et al. (2015)	Switzerland	LDV	Combined	15	√	√	√	√	√	√	LCA	√	√	√		√	√	√		
	Ercan and Tatari (2015)	USA	Bus	Combined	12	√	√	√	√			LCA		√	√		√	√		√	
	Mitropoulos and Prevedouros (2015)	USA	LDV	Combined	10.6	√	√	√	√	√		LCC	√				√	√	√		
	Xu et al. (2015)	USA	Bus	Fuel	N/A	√	√					LCA		√	√		√	√	√	√	
2014	Reuter et al. (2014)	Singapore	Taxi	Combined	8	√	√	√	√			LCA	√	√	√		√				
	Ribau et al. (2014)	Portugal	Bus	Combined	N/A	√	√	√	√	√		LCA		√				√	√		
2013	Elgowainy et al. (2013)	USA	LDV	Fuel	15	√	√					Combined	√	√	√		√	√	√		
	Messagie et al. (2013)	Belgium	LDV	Combined	7	√	√	√	√	√		LCA	√	√			√	√			
	Nanaki and Koroneos (2013)	Greece	LDV	Combined	13	√	√	√	√	√		Combined	√	√			√	√			
2012	Gao and Winfield (2012)	USA	LDV	Combined	N/A	√	√	√	√	√		Combined	√				√	√	√		
	McKenzie and Durango-Cohen (2012)	USA	Bus	Combined	15	√	√	√	√			LCA			√			√	√		
	Shen et al. (2012)	China	LDV	Fuel	10	√	√					LCA	√		√		√	√	√	√	√
2011	Baptista et al. (2011)	United Kingdom	Taxi	Combined	N/A	√	√	√	√	√		LCA		√			√	√	√		

Note:
[1]The N/A remarks are indicated for studies that use vehicle lifetime travel distance instead of years
[2]Extends beyond the typical fuel WTW and vehicle CTG life cycle

Table 2: Dimension of analysis and indicators for evaluating criteria

Year	Author(s) of publication	Dimension of analysis (single/ multiple)	Triple-bottom-line (TBL)			Indicators for evaluating criteria																				
						Economic							Environmental									Social				
			Economic	Environmental	Social	LC costs /TCO	Fuel/energy cost	Govt. taxes	Incentive/subsidy	Infrastructure cost	GDP & GOS	Imports	GWP/GHG emission	Energy use	Air pollutants emission	Water withdrawal	Ecosystem[1]	Acidification potential	PMF	POF	hazardous waste generation	Air quality-human health (pollutants)	HTP	Employment	Injuries	Income
2016	Ally and Pryor (2016)	Single	√			√	√	√																		
	Lajunen and Lipman (2016)	Multiple	√	√		√							√	√												
	Onat et al. (2016)	Multiple	√	√	√	√	√	√			√	√	√	√	√	√	√		√		√			√	√	√
	Orsi et al. (2016)	Multiple	√	√		√	√							√												
	Patil et al. (2016)	Single		√									√	√												
2015	Bauer et al. (2015)	Multiple		√	√								√		√			√	√	√		√	√			
	Ercan and Tatari (2015)	Multiple	√	√		√				√			√	√	√	√										
	Mitropoulos and Prevedouros (2015)	Multiple	√	√	√	√	√						√		√							√				
	Xu et al. (2015)	Single		√									√		√											
2014	Reuter et al. (2014)	Single		√									√	√												
	Ribau et al. (2014)	Multiple	√	√		√	√						√													
2013	Elgowainy et al. (2013)	Multiple	√	√		√	√	√					√	√												
	Messagie et al. (2013)	Multiple	√	√	√	√	√	√					√		√							√				
	Nanaki and Koroneos (2013)	Multiple	√	√		√	√						√		√											
2012	Gao and Winfield (2012)	Multiple	√	√		√							√	√												
	McKenzie and Durango-Cohen (2012)	Multiple	√	√		√	√	√	√				√		√											
	Shen et al. (2012)	Single		√									√	√												
2011	Baptista et al. (2011)	Single		√									√	√												

Note:

[1]includes fishery, grazing, cropland, forestry

3. Discussion

Notwithstanding the growing body of literature, LC analysis of alternative fuel vehicle technologies for decision making is relatively new (and still evolving) in terms of methodological and practical applications. From an examination of the reviewed studies, there is a lack in consistency and standardised approach in general. Independent of the different assumptions, the scope of analysis and the system boundaries differ quite significantly. This variation has several consequences: 1) the results are difficult to interpret and compare and 2) conclusions from comparative studies are somewhat invalid and meaningless.

In terms of the approach, it was discovered from the review that the LC evaluation methods are sometimes mixed and/or substituted with other terminologies or techniques (i.e., WTW, TCO). Within the scope of this review, however, the author categorised the LC approach as LCA and LCC since these are the most common for environmental and economic impact assessments. Among the LCA studies, a few of the models have evolved from the traditional into a hybrid IO (Ercan and Tatari, 2015) and TBL-based economic IO, developed based on the LCSA framework (Onat et al., 2016). On the other hand, LCC is less preferred since it is known to be meant for financial analysis, even though it is also able to address other TBL dimensions with the existence of environmental and social LCC as discussed by Testa et al. (2011) and Swarr et al. (2011). Only the study by Mitropoulos and Prevedouros (2015) applied LCC in this context, by broadening the scope of a traditional LCC to integrate external emission and societal costs with the consumer lifecycle costs.

While analysing the articles, the lack of consensus is also substantial in the evaluation criteria, as it appeared to vary in terms of the type and quantity of indicators used in the analysis. On a positive note, this inconsistency opens up a wide range of indicators that the models can incorporate. Being the most standardised tool, LCA is able to cover the environmental dimension quite well with several indicators. From the reviewed publications, the GHG emission impact on climate change or GWP is the most considered. Within this dimension, there was an attempt to analyse the environmental burdens beyond the GWP. This was achieved by Bauer et al. (2015) and Messagie et al. (2013) with the inclusion of other potential impacts from GHG and pollutants emissions (i.e., acidification potential and damage on ecosystem).

Despite the lack of a standardised method, a number of LC analyses have moved beyond the single-dimensional perspective. In these studies, alternative fuel vehicle technologies were assessed in terms of cost and emission as well as energy-related costs and benefits (Lajunen and Lipman, 2016, Mitropoulos and Prevedouros, 2015, Orsi et al., 2016). The economic aspects are incorporated by integrating LC cost analyses with environmental impact assessments. The most commonly used economic indicators measured in the reviewed studies are vehicle ownership and fuel costs. However, the review shows that the inclusion of cost components as part of the ownership costs is not consistent among the reviewed studies. Some studies omitted vehicle repair and maintenance costs (Gao and Winfield, 2012, Elgowainy et al., 2013), whereas other studies include infrastructure costs (Ercan and Tatari, 2015, McKenzie and Durango-Cohen, 2012). Meanwhile, government taxes are excluded in the work by Orsi et al. (2016) but are considered in several other studies (Ally and Pryor, 2016, Onat et al., 2016, Elgowainy et al., 2013), along with subsidies (McKenzie and Durango-Cohen, 2012). In another observation, for a study that claimed to perform a lifecycle cost and emission-impact analysis of technology options, Lajunen and Lipman (2016) only

considered the purchase, operating, maintenance, and possible carbon emission costs during the in-use stage. Other vehicle-related costs and environmental effects were ignored.

The analysis of previous case studies also reveals that the integration of the social dimension is rather limited. The existing LC analysis does not adequately cover the assessment of the social effects of technology choices. Most analyses that include social aspects are restricted to the air quality-related human health impacts from vehicle tailpipe emission. Besides the human toxicity effects, noise pollution, congestions, etc., are less common, even though these are important for sustainability. Nevertheless, measuring these effects that do not have a market value and involved high level of uncertainties is not a straightforward task (IPCC, 2007). The limited availability of established indicators and the complexity in quantifying social effects could be the reason it has not been widely incorporated in the LC analyses of alternative fuel vehicle technologies.

Within the transport and energy sectors, there are only a limited number of studies that have attempted to appraise the LC sustainability performance of alternative vehicle technologies in the literature. This is particularly evident from the review of this paper. Except for one study, none of the analyses provided a consistent and comprehensive LC-based evaluation of economic, environmental, and social burdens caused by current and future technologies in a wider sustainability context. Onat et al. (2016) has extended the scope of LCA and advanced further toward LCSA. Considering the flexibility of LC-based tools, more relevant indicators can be observed for sustainability-oriented decision making.

In another observation, most LCA-based analyses conducted in the reviewed case studies involved multiple metrics. Without the use of a common metric to unify multi-dimensional indicators and to simplify the comparison, evaluated technologies were often compared separately according to a specific dimension. The result of each analysis is only synthesised in the final step of decision making, thus the models are unable to determine the single ‘best option’ based on a combined assessment. A number of authors have used the optimisation and multi-criteria decision making methods to find trade-off solutions and to rank the technology options (Ribau et al., 2014, Onat et al., 2016, Nanaki and Koroneos, 2013). Yet, the adoption of these methods is not without controversy. In contrast, the LCC-based models only deal with monetary units. Since all indicators are measured in a common metric, the comparison can be done simultaneously, leading to one particular choice with the lowest LC cost that represents the best performance. This simplicity makes it more practical and effective for decision making.

In the final observation, studies in the European or American context, as represented by the majority of the reviewed studies, can provide general comparative results. However, country-specific studies can deliver relatively more meaningful results that are more representative of local conditions. Using case study with country-specific input parameters, such as energy mix characteristics, feedstock resources for biofuels production, etc., will also create opportunities for more novel studies to contribute to the existing literature.

4. Conclusion and Recommendations for Future Research

A review of 18 studies, conducting a comparative LC analysis of alternative fuel vehicle technologies, revealed that, irrespective of the aim and objectives, the results are generally incomparable. This situation occurs primarily because of the differing scopes, system boundaries, methods and criteria for evaluating technology options. Regardless of this issue, the existing literature is fairly unanimous and conclusive in that there is no absolute or particular alternative fuel/vehicle technology that achieves the best results in each and every one of the indicators measured (e.g., lowest cost, lowest emission impact for both environmental and social aspects, and highest energy efficiency). Due to the conflicting objectives, sustainability-oriented decision making becomes difficult. Thus, the need for quantifying the 'best option' that achieves the best possible balance across the TBL dimensions is essential.

In this paper, the review of recent comparative LC analyses of alternative fuel vehicle technologies was conducted with the aim to examine the integration of the TBL into the model framework. Despite differing scopes, system boundaries, methods and evaluation criteria, the following conclusions can be drawn:

(i) the LC analyses in the reviewed studies mostly considered environmental or economic aspects, as compared to social and thus were unable to provide a balance from the TBL perspective;
(ii) the LC analysis framework is flexible and can be extended to incorporate other indicators.

Although the reported applications were mostly still far from ideal within a sustainability context, more indicators can be added into the framework to deliver a comprehensive analysis, for better informed decision making. The current work by the author embodies this TBL multi-dimensional perspective by carrying out an LC analysis based on economic, environmental, and social effects to properly evaluate and compare different technology options. The proposed framework will be applied to evaluate technology choices for taxi fleet operating in a real-urban environment, which, to the author's best knowledge, has not yet been done from a TBL perspective. In addition, recent analyses conducted for taxi specific applications (Wang et al., 2015, Castel-Branco et al., 2015) only compared a particular technology e.g., hybrid or electric powertrains with the conventional ICE whereas the current work covers various alternative fuels/vehicle technology options for taxi fleet.

In terms of geographic context, the TBL indicator-based life cycle analysis is applied to evaluate alternative fuel vehicle technologies for city taxi fleets operating in a rapidly growing Asian city. Greater Kuala Lumpur/Klang Valley (Greater KL/KV) is selected as the representative case study. As the capital and financial hub of Malaysia, Greater KL/KV is one of the fastest growing urban areas in Southeast Asia (The World Bank, 2015), with the highest vehicle ownership rate (693 per 1000 people in 2010) as compared to other cities in the region (OECD, 2014).

It is important to mention that not all the indicators compiled from the review of past studies are covered in the proposed framework. Nevertheless, the author believes that the recommended improvements are important for future research work. In the present work, TBL is integrated into the analysis framework using indicators that 1) are quantitative, 2) can

value the effects in monetary units, and 3) are relevant in fleet decision making. The author asserts that all non-economic (environmental and social) burdens are valued as externalities in monetary terms, allowing the model to deal with all parameters in a common metric. By doing so, greater clarity can be achieved, making the decision-making process easier. Monetary-based analysis also allows a comparison of more emission-impact related factors, since each of the evaluated environmental and public health effects is assigned its respective monetary value (damage cost).

Finally, the proposed framework contributes to providing a more coherent and comparable analysis of various technology options to aid fleet decision-makers in purchasing and fleet renewal programmes. It is also intended to encourage them in fulfilling sustainable development responsibilities. The TBL perspective can shift them away from looking at only one aspect of the criteria and, ultimately, steer their decisions toward more sustainable choices. Although the findings of this study are derived for Greater KL/KV, the framework can also be used as evaluation template for taxi fleet in other similar urban areas.

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Sino Group: Showcasing Sustainability Efforts in Hong Kong's Property Development Industry

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Abstract

Hong Kong, being one of the leading international financial centres, is an extremely dense city with precious land resources. The properties and related industries contribute around a quarter of Hong Kong's GDP. The city's property developers are therefore important and influential corporate citizens, who have both the responsibility and resources to drive new environmental initiatives. Sino Group, one of the top five property developers in Hong Kong, was at the forefront of initiating projects to promote sustainable development and combat climate change. It has devoted substantial efforts to making its properties more eco-friendly through well-thought-out architectural planning, energy-saving initiatives and green property management. In one of its major development projects, Olympian City 2 Shopping Arcade, Sino Group piloted several environmental initiatives in Hong Kong including a waste management system, on-site glass-bottle recycling facilities, and a compact hydropower turbine. Based on field study at Olympian City 2, this case study discusses the sustainability efforts of Sino Group and sheds light on how Hong Kong property developers could meet the city's waste-management challenges and make the city's buildings more eco-friendly.

Key Words

Waste management, Recycling, Algal treatment, Hydropower turbine, Food waste, Carbon reduction, Hong Kong

Introduction

Hong Kong is well known for its position as a leading international financial center and the major gateway to the world's second-largest economy, China. Yet, as one of the world's most densely populated places, Hong Kong's waste management has been a huge headache and challenge for the government (Wan *et al*., 2014). On the one hand, the city's waste has increased exponentially as its economy has grown. On the other, landfill space is extremely limited and the voices aiming to further restrict the landfill area in the city's waste management chain are strong, loud and clear. The Hong Kong government estimates that each citizen on average produced 1.36 kg of solid waste a day (EPD, 2015). The government has been striving diligently to introduce appropriate measures, and has run educational campaigns to encourage citizens to produce less waste. Sino Group, one of the top five property developers in the city, has put in a lot of efforts to reduce the bulk volume of solid waste by managing that waste at its source.

The property industry has long been a major powerhouse, driving economic growth in Hong Kong in the past 50 years. One quarter of the city's GDP comes from the property and real estate-related industries (CSD, 2016). Hong Kong property developers therefore play a unique role in the city: With their undeniable responsibility for environmental protection, they are influential corporate citizens who are very resourceful in driving initiatives on sustainable development in the city.

Olympian City 2 Shopping Arcade ("Olympian City 2"), located in the city's prime area, is one of Sino Group's major property-development projects. During its planning stage, Sino Group designated one of the building's basement floors to green waste management. As one of the most expensive cities in the world in which to own or lease property, it is customary for Hong Kong property developers to maximize the commercial usability of floor space. With a car park space easily priced at a few hundred thousand to even a few million Hong Kong dollars, property developers usually plan and design basements and lower floors of buildings as car parks. This explains why the group's deployment of an entire Olympian City 2 basement for environmental initiatives is so rare in the city. The group has also set up a new subsidiary, Perfect Green Limited, to share best practices and offer environmental-performance management services to other Hong Kong developers and properties.

A metropolitan area like Hong Kong typically has an extremely high density in its prime locations. Sino Group turns this into an advantage for its sustainability initiatives. As many restaurant-loaded shopping malls in the territory serve tens or even hundreds of thousands of people every day, crowd sizes allow environmental measures in commercial complexes to reap economies of scale. This case study is developed based on field study of Olympian City 2 and data collection from its key responsible personnel. By examining various Sino Group environmental efforts, this case demonstrates how property developers can balance commercial and environmental interests, and contribute to the city's sustainable development.

Background

<u>Waste Management by the Hong Kong Government</u>

In May 2013, the "Hong Kong Blueprint for Sustainable Use of Resources 2013–2022" was published, and promised "to drive behavioural change to reduce waste at source through policies and legislation; to roll out targeted territory-wide waste reduction campaigns; and to

allocate resources to enhance waste management structure." The Hong Kong government set a target of reducing municipal solid waste (MSW) per capita by 40% by 2022.

Through its legislative framework, the Waste Disposal Ordinance controls waste management in Hong Kong (Chung, 2010). Since 2005, the government's Environmental Bureau has adopted a "polluter-pays principle" in managing the city's MSW. The Environmental Levy Scheme has also been launched in all retail outlets with respect to the use of plastic shopping bags (EPD, 2016a). In March 2016, the city saw the legislation of a similar scheme enacted for electrical and electronic-equipment waste. Similar legislation on glass beverage-container waste is underway.

In addition to providing economic incentives to curb MSW, the Hong Kong government has introduced a number of complementary measures. These include the development of recycling and treatment facilities for electrical and electronic equipment, the building and expansion of the collection network for glass containers, and the development of Community Green Stations in each district for categorizing and sending waste to licensed recyclers or to educational workshops for reuse (Cheung, 2015).

MSW reduction calls for increased recycling. To encourage the development of the recycling industry, the Hong Kong government opens the EcoPark in early 2016, a 20-hectare affordable-land area in Tuen Mun, to incentivize long-term investment in the industry. In addition, an HK$1 billion recycling fund is made available to facilitate the "upgrading of operational capabilities and efficiency of the recycling industry" (EPD, 2016b).

For food-waste management, the government has initiated territory-wide educational programs to encourage domestic food-waste separation. It has also run pilot tests on different mechanisms for domestic waste separation, in a bid to identify convenient processes that residents can easily adopt. It has also assisted property-management companies to provide waste-separation facilities to residents of the properties they manage.

Sino Group's Sustainability Committee

Hong Kong's property market has traditionally been dominated by a few property developers listed on Hong Kong Exchanges and Clearing Limited (HKEx). The top five property developers took up over 80% of the market, in terms of the number of flats pre-sold from 2011 to 2015 (HKEx, 2015).

Sino Group, as a top-five Hong Kong property developer, owns three publicly listed companies on HKEx, namely Sino Land Company Limited (00083.HK), Sino Hotels (Holdings) Limited (01221.HK) and Tsim Sha Tsui Properties Limited (00247.HK). Sino Group's core business is property development of residential buildings, offices, and industrial and retail properties. It has developed over 200 projects in Hong Kong, China and Singapore. The group also runs an array of property services, including property management, car park management, cleaning and environmental services, and security services.

In 2010, Sino Group set up the Sustainability Committee to drive the planning and execution of its strategy for sustainability development. Chaired by Dr. Daryl Ng, Executive Director of Sino Group, the Committee sets the direction of the group's sustainability strategy, policies and initiatives. Under the directive of the Committee, Sino Group has voluntarily published

annual sustainability reports in accordance with the GRI G4 Reporting Guidelines for five consecutive years since 2011.

The Committee believes that property developers should play an active role in combating climate change, and that the group's environmental and corporate-responsibility performance improvements can ultimately bring value to its stakeholders. To walk its belief, the Committee masterminds a series of green initiatives and drives and facilitates their execution.

The Committee also strives to synergize the group's green initiatives with other sustainability-related programmes in Hong Kong whenever practicable. In particular, the Hong Kong government has launched the Food Wise Hong Kong Campaign to promote public awareness and instil behavioural changes in the community to lower food waste. To spearhead the efforts in the private sector, the Subcommittee of Food Waste Reduction Good Practices in Institutions and Commercial and Industrial Establishments was set up. Dr. Daryl Ng, as the key representative of Sino Group, serves as the subcommittee chairperson to formulate strategies, and promote best practices and experience-sharing on reducing food wastes generation among corporations and organizations in the city.

Sino Group has long been a committed corporate citizen in undertaking its corporate social responsibilities. It takes pride that all its properties have "green architecture [and] green property management" (Sino, 2015). The group's waste management and collaborative green initiatives at Olympian City 2 provide a vivid illustration of how an environmentally responsible Hong Kong property developer can take part in reducing the impact of its business operations on the environment and saving the earth's resources for future generations (Sito, 2013).

Case Study: Green Projects at Olympian City 2

Olympian City is a mega residential, commercial and retail property project of Sino Group. Conveniently located within the West Kowloon "golden circle", the project has five metro stations nearby and provides around 40,000 residential apartments. The shopping arcade has eight hundred thousand square feet of retail space that accommodates 250 shops and 40 restaurants. It is also within a commercial-building catchment area of five million square feet. Every day round-the-clock, the shopping arcade serves an enormous group of customers and visitors.

Understanding that this massive crowd of visitors will create large volumes of waste, Sino Group, as a responsible corporate citizen, develops measures to contain the negative effects of its shopping mall's operations on the environment. On top of the usual waste separation at source method of using tri-colored bins for the recovery of recyclable materials (ISD, 2013), the group has incorporated green architectural design in Olympian City 2, the project's largest phrase.

The shopping arcade's basement is dedicated to waste management. The floor allows for the installation of waste-management facilities, such as a highly efficient food-waste decomposer to handle food waste from restaurants, and a sophisticated glass-bottle recycling solution. In addition, the group has used Olympian City 2 as a test ground for green projects jointly conducted with academia. These include the research and development of the world's first in-building hydropower system, with Arup and The Hong Kong Polytechnic University, and the

use of microalgae to purify food waste filtrates, in collaboration with the Open University of Hong Kong.

Waste Management at Source

(I) 99.8% Efficient Food Decomposer

Since 2013, Sino Group has introduced a highly efficient food-waste decomposer at Olympian City 2. The complex is the first shopping mall in Hong Kong to have an on-site decomposer capable of degenerating 99.8% of its food waste to carbon dioxide and moisture. Such an efficiency rate is higher, in fact, than that of traditional incineration technology. The machine allows Sino Group to engage its tenants, who may easily participate in the food-waste recycling program. After the launch, the group successfully helps its food and beverage tenants to dramatically reduce the volume of food waste requiring disposal at landfill sites.

The first-generation food-waste decomposer at Olympian City 2 has a capacity of "digesting" 100 kg every day. With the overwhelmingly positive response of the mall's tenants, the group upgraded the capacity of the food waste decomposer to 500 kg in 2014. This means that, when operated at full capacity and efficiency, the machine can degenerate 500 kg of food waste into moisture and carbon dioxide daily, with a residual one kg that can be used as fertilizer. The machine operates at a temperature range of 20-35°C, meaning that no extra air conditioning is required for running the machine most of the time during the year.

Sino Group has carefully designed the recycling-program process to encourage voluntary participation (Southerton, 2003; Siu and Xiao, 2016). At present, around 70% of the mall's food and beverage tenants participate in the program. The shopping mall collects food waste from participating tenants every day. Depending on the volume of food waste produced, Olympian City 2 provides each tenant with sets of big recycling buckets (Figure 1). Each set has two buckets: When one is full, workers from the mall collect the filled bucket and replace it with a clean one. Each bucket has a built-in device to drain and separate water and liquids from food waste. This design helps reduce odour and allows the buckets to be transported without hassle from the tenants' locations to the mall's basement, where the food-waste decomposer is located. Every month, Olympian City provides each participating tenant with data on the volume of food waste processed. According to the mall spokesman, this is a major incentive for tenants because they can readily use the information to report on their corporate social-responsibility undertakings (Shearer, 1990).

Figure 1: The Highly Efficient Food-waste Decomposer at Olympian City 2

Sino has deliberately set the limit of handling around 350 kg of food waste from mall tenants every day. The decomposer's remaining capacity is used to handle the food waste from non-profit organizations in the Olympian City 2 vicinity. For example, Feeding Hong Kong, one of the food banks that redistribute surplus food to people in need, periodically transports expired foodstuffs to Olympian City 2 for decomposition. When the volume of food-waste residue (i.e., the fertilizer produced) reaches a truckload, Olympian City 2 arranges to donate the fertilizer to organic farmers in the New Territories.

(II) Glass-Bottle Recycling Solution

Glass-bottle recycling in Hong Kong has gotten little traction, with less than 10% of the 353 tons of glass waste produced every day entering the recycling chain (Arora, 2015). The bulky nature of empty glass bottles is a major deterrent to glass-bottle collection at source, given the high cost of space in Hong Kong. Processing glass bottles traditionally involves high energy use while producing serious noise pollution (Ling *et al*., 2013). In addition, the process produces sharp cullet (recycled or broken glass) and dust powder, both hazardous to the health of the workers involved. Transportation of bulky glass bottles is also inefficient and contributes to carbon emissions.

To surmount these challenges and implement a glass-bottle recycling programme among the food and beverage tenants at Olympian City 2, Sino Group introduces a waste-glass processor (Figure 2) from the UK. The processor, leased at a cost of over HK$10,000 monthly, uses a

mechanical resonance transfer technology to implode waste glass bottles. Not only is the process simple and easy to operate, this glass recycling solution also has the following merits:

- It consumes little energy, and has a short warm-up time, so the machine can be turned off completely when not in use.
- It produces very low levels of noise.
- The process does not produce dust powder.
- The cullet produced is rounded rather than sharp.
- The bulky glass bottles have their volume reduced by 80%, greatly easing the burden on expensive storage space.
- Waste transportation is much more efficient, reducing carbon emissions.

Figure 2: The Glass Recycling Machine at Olympian City 2

In addition to all these merits, the machine has almost no capacity constraints, apart from the operator's capacity. Therefore, this solution has successfully overcome all the challenges involved in glass-bottle collection at source.

When the volume of cullet reaches a full truckload, Sino Group arranges transportation to a glass-recycling manufacturer, where corks and paper labels are separated from the glass. The cullet is then used to produce cullet-clay bricks (Figure 3) for local construction projects (Poon and Cheung, 2007; Lee *et al*., 2011).

Figure 3: Cullet-clay Bricks Produced from Recycling Glass Bottles

(III) Other Initiatives to Enhance Environmental Performance

Sino Group has launched additional eco-friendly initiatives in Olympian City 2:

Collecting Waste Grease - Raw Biodiesel Material: Olympian City 2 is designed to have underground grease traps and tanks below its basement. All waste grease from the mall's food and beverage tenants is collected and transported to a biodiesel plant at Tseung Kwan O. Around 10% of the waste grease can be recycled to produce biodiesel.

Reducing Wasteload Volume: Olympian City 2 strives to separate out recyclable and reusable materials from the daily refuse produced by the mall's operations. Non-recyclable and non-reusable materials are then assembled in the basement. In order to further reduce the wasteload volume, Sino Group specially installs tracks on the basement floor to allow the deployment of high-capacity refuse compactors. These compactors have outstanding garbage compaction capability that can reduce waste volume by 80% (Figure 4). In addition, during the compressing process, water and waste liquids are separated from the garbage, and are collected by the grease trap as raw biodiesel materials (Wang *et al*., 2010). With the help of these high-capability compactors, wasteload required to be disposed of at landfill sites is reduced to two trucks a day instead of ten trucks. As a result, carbon emissions in the transportation process are contained, and the space required at landfill sites is reduced.

Figure 4: The Refuse Compactor with High Garbage Compaction Capability

Community Education: To raise public awareness of the importance of waste management and how the efforts of every organization and individual count, Sino Group works with different non-profit organizations and academic institutions to organize site visits to Olympian City 2. The mall's proven food-waste management system also sets an example for other organizations to follow. For example, Sun Hung Kai Property, another large property developer in Hong Kong, has recently run a pilot project to install a food-waste decomposer in one of its properties.

Joint Efforts with Academia to Improve Building Environmental Performance

(I) The World's First In-Building Hydropower Project

Sino Group has pioneered, in partnership with Arup and The Hong Kong Polytechnic University, research and development of a hydropower system for buildings that transforms water flow in pipelines into hydroelectricity (Sino, 2014). While space is extremely limited and valuable in Hong Kong, the hydropower system developed is extremely compact (Figure 5). The system involves the installation of a turbine at the building's main incoming water pipe, capturing the water current passing from the public water supply to the building whenever a water tap is turned on in the building. When passing through the system, the water current drives a novel vertical-axis turbine to generate hydroelectricity. This compact system generates electricity sufficient to power a building's lift lobby, and reduces carbon emissions by 700 kg a year, an amount that otherwise take more than 30 trees to absorb (Sino, 2015).

Figure 5: The Compact Turbine for Generation of Hydro Power at Olympian City 2

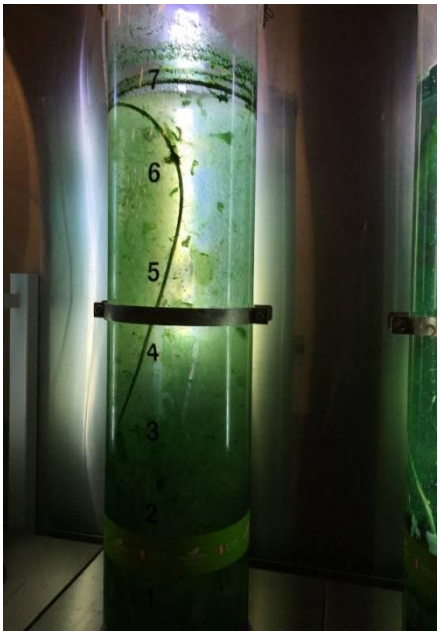
The device currently in-use in Olympian City 2 is the second generation derived from the development project. The project is the first in-building hydropower system in the world, as well as "the first-of-its-kind research collaboration between a commercial organization and academia" (Sino, 2014). Using Olympian City 2 as a testing platform, Sino Group enables university research students to collect empirical data on production, which provides the critical foundation for researching and developing the system's third generation. The current version has the drawback of reducing water pressure. Though the shopping arcade has never received any expression of concern from its tenants, there is room for improvement in generating more electricity. This will be a focus of the next generation of this hydropower research.

To further test the stability of the hydropower system, Sino Group has installed it in each of the twelve new buildings of another development project, the Avenue. The power generated is used to light each building's lift lobby. Given the almost full penetration of the water infrastructure and the densely populated skyscrapers of Hong Kong, the system represents a meaningful start in capturing unused water pressure to generate electricity.

(II) Another World First — Using Microalgae to Purify Food-Waste Filtrate

The "purification of food-waste filtrate with microalgae" project is another innovation that is the first in the world (Figure 6). It is also another showcase of Sino Group's cooperation with academia. A set of testing systems is housed at Olympian City 2, and the group also supplies food-waste filtrate to support research at the Open University of Hong Kong laboratory. Though research is still in progress, preliminary findings on applying algal treatment to food waste filtrate are very encouraging. Some ground-breaking results in improving water quality by removing nitrogen, phosphorus and other suspended particles from the filtrate have been observed in the testing environment.

Figure 6: The Microalgae Treatment Setup at Olympian City 2



In addition, the algae cultivated may be used as low-cost raw material in producing biodiesel. This green solution to sewage treatment may help reduce carbon emissions. The empirical data collected indicates that this microalgae treatment process can achieve a reduction of carbon emissions of as much as 12,800 kg per annum.

Sharing the Waste-Reduction and Recycling-Management Experience

Sino Group has its own subsidiary, Best Result Environmental Services Ltd. ("Best Result"), which runs cleaning services for most of its development projects in Hong Kong. Years dedicated to building-cleaning services, together with the group's strategic direction of sustainable development, have enabled Best Result to accumulate ample and valuable experience in improving the environmental performance of buildings.

In 2012, Sino Group formed Perfect Green, a subsidiary of Best Result specializing "in designing and implementing waste reduction and recycling management programmes" for buildings (Perfect Green, 2016). It is Perfect Green that sources and provides the food-waste decomposer and the glass-recycling solution to Olympian City 2. Sino Group allows Perfect Green to operate at arms-length, this practice puts Perfect Green in a better position for serving other property developers and in helping them to design projects with high building-environmental performance.

Conclusion

Waste is a common problem in developed cities. Consumption becomes affordable for the general public, inevitably leading to the production of more waste. In Hong Kong, the MSW has shot up by 80% in the past 30 years, while the GDP only doubled during the same period. A glimpse of daily domestic waste generation shows that Hong Kong has a higher waste production per capita than neighboring cities like Tokyo, Taipei and Seoul.

In Hong Kong, the property industry plays a very significant role in the economy, with its contribution to the GDP reaching around 25.7%. Property developers, especially the few leaders at the top, are in possession of ample and extremely valuable resources. They therefore occupy a prominent and unparalleled position in driving new initiatives to create positive impact on society.

The dense population of Hong Kong and its extremely precious land resources imply that residential and office buildings and shopping malls are all crowded together, allowing for economies of scale in launching new initiatives for improving the environmental performance of buildings. Sino Group, as a major Hong Kong property developer, has taken the lead in trying out innovative solutions and joining hands with academia to support local research on environmental innovation.

Sino Group's commitment to help build a more eco-friendly Hong Kong goes beyond work done, improvements introduced and pilot tests run on its own properties. By setting up a subsidiary that centralizes its green operations, Sino Group shares its experience in designing eco-friendly building solutions and helps introduce the latest environmental technology to Hong Kong. In recognition of its continuous efforts in promoting sustainable development and adherence to high environmental, social and corporate-governance performance standards, Sino Land, the group's leading subsidiary, has been selected as a constituent stock in the Hang Seng Corporate Sustainability Index.

This case study illustrates the sustainability efforts of Sino Group in the Olympian City 2 Shopping Arcade. It showcases how a for-profit organization in a typical "environmental-hazard" business like property development can leverage its strengths and niches to contribute to a greener city.

Acknowledgement

This paper was fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (UGC/IDS12/14).

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Sustainable Development Goals as a 'Developmental Thali': Intellectual history of Sustainable Development 1949-2016

Asad Ali Abbasi

Abstract:

In January 2016, United Nations General Assembly finalized Sustainable Development Goals (SDGs). Like its predecessor, Millennium Development Goals, SDGs will direct developmental policy for next fifteen years. But unlike Millennium Development Goals, SDGs have introduced a new concept: Sustainable Development. What is sustainable development? Is it a new idea or old one? And is this framework different from previous developmental frameworks?

In this paper, I trace intellectual history of sustainable development from end of Second World War to the present. The historical analysis suggests that concern for environment emerged as a critique of modernization theory. And after years of struggle, environmental concern has gained institutional support but faith in economic growth hasn't relented.

I argue two things in this paper. First, though, UN approval gives it institutional support, sustainable development is not a new idea. Second, as a framework, SDGs is akin to a 'Developmental Thali' where various ideas, no matter how different, are presented together under one framework.

Keywords: Developmental thinking, Sustainability, Sustainable Development

1. INTRODUCTION

In January of 2016, General Assembly of United Nations replaced Millennium Development Goals (MDGs) with a broader framework guiding 'policy guideline for next fifteen years' — Sustainable Development Goals(SDGs).[1] MDGs provided seven goals, 18 targets; SDGs has seventeen goals and 169 targets.

In this paper, I will sketch the idea of sustainable development from post world war II to present. I adapt Knutsson (2009) methodology to trace changes in idea of sustainable development. Knutsson (2009) argues that since the end of Second World War there has been 'enrichment of development thinking' and this enrichment leads to 'widening of potential repertoire i.e. backcloth of knowledge and experiences that are available at a certain moment in history'.[2] I agree that there has been 'widening of potential repertoire' but only until 2000. Since then, no new ideas have emerged in developmental thinking and no potential repertoire widening. This creates a problem with Knutsson's analysis because if there is no potential repertoire than the analysis is not adequate to explain the present developmental period.

At a mere glance, one might get the impression that sustainable development is a new idea, or at least a new approach. This wouldn't be entirely irrational to believe. Since it is the same argument emphasized by United Nations. But upon closer scrutiny, one finds that Sustainable Development is not a 'new approach' as promised by General Assembly of UN, or a 'New Agenda'. All the ideas of sustainable development have been present in previous reports. I show this by comparing previous ideas of sustainability with present idea of sustainability. There is, as we will see, one key difference between previous ideas of sustainable development and present one: The old ideas emerged as a critique to economic growth and the present one merges economic growth with sustainable development.

This paper also questions the deterministic position taken by Post-Developmental theorist like Rist (2008). Rist (2008) argues that though each period of development brings new hopes and optimism but having a closer look, one finds that each concept is 'merely a variation on a single theme' to 'assert their legitimacy within the field of development'[3]. Though Rist and other Post Developmental theorist present a critical analysis, useful for understanding development, I agree with Hettne (2008) that Post Development approach 'lacks the will' to alter 'hegemonic paradigm of development'[4].

2. DEFINITION OF SUSTAINABLE DEVELOPMENT

It is not the task of this paper to define sustainable development. However, I will describe few of the complications that are associated with defining development and sustainable development before going into the method of inquiry.

[1] Transforming Our World, 2016
[2] Knutsson, The Intellectual History of Development, 2009, pg 2
[3] Rist, The History of Development, 2008, pg 5.
[4] Hettne, Thinking about Development, 2008, pg 16

In developmental literature, concept of sustainable development is used in many, often, 'mutually exclusive' and contradictory ways.[5] Part of the problem in defining sustainable development is lack of fixed definition for development. But, in order to grasp the concept of sustainable development, how important is its definition?

According to Aristotle, definition of an object is the formula in words that tells us about the object.[6] That is, to understand a thing, one has to understand its 'essence' and the best way to understand 'essence' is to understand its definition.[7] Therefore, definitions are fundamental in understand a concept. Borrowing from Aristotle, Rist (2008) is adamant to define development. Such definition, Rist hopes that 'even a Martian' could understand.[8]

Is Aristotle correct? Definition to find 'true essence of things' — What Aristotle wanted— is, according to Karl Popper, Methodological Essentialism. People acquire knowledge, according to the theory of Methodological Essentialism, through three things a) to know the essence of a thing b) defining the thing and c) naming that thing. In contrast, Methodological Nominalism, one used in natural sciences, focuses not on the essence of things, as Aristotle suggests, but how things behave in various circumstances.[9]

Hettne (1995, 2008) follows Popper's logic when he points out that 'there can be no fixed and final definition of development; only suggestion of what it should imply in particular contexts'.[10] By suggesting that definition depends on context doesn't resolve the issue completely because in the social sciences, contexts vary much more than they do in natural sciences. Therefore, depending on the context, development could mean different, even contradictory, thing.

For example, Rist defines, "Development consists of a set of practices, sometimes appearing to conflict with one another, which require – for the reproduction of society – the general transformation and destruction of the natural environment and of social relations. Its aim is to increase the production of commodities (goods and services) geared, by way of exchange, to effective demand."[11] This is surely a very complicated definition. Contrast with definition of simple definition given by The Brundtland Report. The Brundtland Report suggests sustainable development is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. But, it is too simply. The mere 'simplicity of this definition is deceptive', according to Michael Redclift, because 'needs' of the present can change and, which is more likely, 'needs' of the future will change too. Then, how do we know what are the 'needs of the present' and 'needs of the future'. And based on this, how do we know what policies to choose?[12] These are few of the complications one has to face when defining development and sustainable development. Therefore, to skip these lexical problems, General Assembly describes Sustainable Development, not in its functions but, in its dimensions. According to this criterion, Sustainable Development has three dimensions: Economic, Social and Environmental.[13]

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[5] Desai and Potter, The Companion to Development Studies, 2014, pg 481
[6] Margueritte Deslaurieers, Aristotle on Definition, 2007, pg 2
[7] Ibid
[8] Rist, 2008, pg 10
[9] Popper, Open Society and Its Enemies, V1, 2002 pg18-32
[10] Hettne, 2008, pg 2
[11] Rist, 2008, pg 13
[12] Desai et.al, pg 481
[13] Transforming Our Future, Preamble

Before beginning the quest for intellectual history, it is important to inform the reader of method and tools that I will be using. I heavily rely on previous works of many authors including Hettne and Knutsson but my analyses as well as conclusions are different.

3. METHODOLOGY AND FRAMEWORKS

I adapt methodology used by Knutsson (2008) to understand evolution of development thinking. Knutsson methodology employed two frameworks: Gramsci's Historical Bloc, as developed by Abrahamsson (2003); and Hettne's (1995) Mainstream-Counterpoint-Dialectic. The primary reason for using Knutsson's approach is clarity. With these two frameworks I can narrate the history with two spheres: one for political ideas and other for developmental ideas. Despite using the same framework, my arguments and conclusion vary significantly from Knutsson (2009).

One way in which this paper's methodology significantly differs from developmental literature is how I have divided historical periods. Almost all the writers have divided developmental periods according to chronology. The first developmental decade begins after the end of WWII. Then, each subsequent period of analysis begins with start of new decade. Thus, 1960, 1970, 1980, 1990, and 2000, all these years are focal point of change. International developmental institutions use the same division to signal end or beginning of new period.

Instead of dividing each developmental period based on timeline, I divide the periods that actually brought change in developmental thinking. As a result, I divide periods into three epochs of development. The First Epoch of Developmental begins with Truman's inaugural speech until the financial crisis of mid 70s. There was a huge change in economic and political thinking, and, consequently, change in developmental thinking. This was beginning of Second Epoch of Development that continued until the late 90s. Then, the Third Epoch of Development begins with new millennium that continues even today. Here, periods are not a side-story in developmental thinking but actually mark when new periods begin. I have divided the periods based on my understanding of events and any better division will only improve the narration of history. Before beginning with First Epoch of Development, let me briefly explain both frameworks.

3a. HISTORICAL BLOC: State, Market and Civil Society

Historical bloc is a concept developed by Gramsci to describe struggle between different social classes. But historical bloc is more than just social forces.[14] Gramsci's historical bloc is a complex relationship between state, market and civil society. This complex relationship is formed by historical as well as 'subjective sense of political identity'.

Nature of historical bloc is not clearly defined. According to some theorists, for historical bloc to function it needs hegemony of one agent[15]. Thus, historical bloc cannot exist without hegemonic social class.[16] But, others, including Gill (1993, pg 40) argue that an idea can become hegemonic within the historical bloc but hegemony of any idea is not fundamental to

[14] Andreas Bieler, Globalisation and Enlargement of the European Union, 2000
[15] S.M Shamsul Alam, Governmentality and Counter-Hegemony in Bangladesh, 2015
[16] Andreas Bieler, pg 14

the existence of historical bloc because historical bloc is an organic compromise between groups that want to establish their own identities.[17] It is, in fact, formed through 'compromise or force of arms'[18]. It is organic, and in its struggle to form hegemony, it 'dissolves and reforms'.[19] We will see how state, market and civil society have fought to establish hegemony in the historical bloc and how external and internal dynamics have made these changes possible. This framework clearly distinguishes between state, market and civil society.

3b MAINSTREAM-COUNTERPOINT-DIALECTIC

How does an idea emerge? And how does an idea change? Kuhn's argument is that scientific knowledge proceeds in cumulative fashion, it proceeds from one paradigm to the next. Based on some scientific achievement, consensus is built and scientific knowledge and institutions proceed from there. However, certain problems in future are not resolved by the initial achievement and new framework is required. 'With new paradigm, former unrefuted answers may drop from view or even intelligibility'.[20] This is how ideas emerge and change.

Thomas Kuhn found a pattern in scientific thinking: Science-Crisis-Revolution. And he explained this pattern through his theory of Paradigm Shifts.[21] Following Kuhn, Hettne (1995) notes a pattern in developmental thinking: Mainstream-Counterpoint-Dialectic.

In contrast to Kuhn's scientific thinking, which after a new paradigm emerges past theories become obsolete, Hettne's developmental thinking allows for new entries but previous theories never become obsolete. The residues continue to exist. Mainstream, according to Hettne, is 'prominent, hegemonic and "politically correct" part of the discourse on the goals and means of development'.[22] By this definition, Sustainable Developmental Goals 2016 are the mainstream discourse. Counterpoint, by definition, 'must be seen as a reaction to, and force for, changing mainstream thinking', one that is mainly 'co-opted by the mainstream' but does not change the fundamentals in the discourse.

Each Mainstream, according to Hettne, has a counterpoint. Before industrial revolution, idea of progress was countered by religious conservative values. Romanticism, socialism and societal values were providing counterpoint discourse against the pangs of industrial progress.[23] When industrialization became the means to progress, then 'groups who lost their previous privileges' provided counterpoint. This implies that counterpoint doesn't command a morally superior idea. This point is important because by suggesting one idea is Mainstream and other is Counterpoint does not imply any value judgment. Within the WWII, counterpoint was in the shape of demonstration held on the streets;[24] in 70s it was environmentalist;[25] and, recently, occupies Wall Street.

[17] Andreas Bieler, pg 14
[18] Stephen Gill, A Ruined Fortress? 2003, pg 61
[19] Roberts and Hite edited, Globalization and Development, 2000, pg 316
[20] Ian Hacking: The Essential Tension, 1979, pp. 223-236
[21] Alexander Bird, Thomas Kuhn, 2000 pg 67
[22] Hettne, 2008, pg 16
[23] Hettne, 2008, pg 18
[24] Hettne, pg 18
[25] Hettne, pg 18

The Mainstream-Counterpoint-Dialectic suggests that counterpoint doesn't remain counterpoint indefinitely. Through a dialectical process, some counterpoints have become part of the mainstream. For example, during the 70s, environmentalist movement, according to Hettne, is an example of counterpoint. But now, using the same framework, Sustainable Development Goals, which emphasizes on importance of conserving environment, is an example of mainstream.

One important distinction that I make in this paper, unlike Hettne, I separate political and intellectual movements. In order to understand political movements, I will employ framework of historical bloc and in order to understand developmental thinking I will employ Mainstream-Counterpoint-Dialectic. Therefore, in this paper demonstrations on the streets are not Counterpoints but actions of Civil Society in the historical bloc. Though in reality, a demonstration is perhaps both but for the purpose of this paper, I will keep this theoretical distinction.

4 FIRST EPOCH OF DEVELOPMENT 1949-1975

End of WWII was beginning of power struggle between United States and Soviet Russia. Hettne is amazed that optimism of the past quickly restored after tumultuous period of the war.[26] In this context, 'underdevelopment' was a threat to 'world order'.[27] Just as Marshall Plan was introduced to protect Europe against threat of communism,[28] development was introduced to protect third world from communism. Soviet Union and United States devised future policy of development.

4a DEVELOPMENTAL THINKING: MAINSTREAM

Though, socialism remained an attractive option for many countries,[29] Truman's inaugural speech in 1949 set the tone for development for the first epoch. Even in the year 2016, Truman's Fourth Point remains an important policy document in development literature.[30]

Rist calls it a 'masterpiece'.[31] It introduced new vocabulary to define development. It was in Truman's fourth point that 'underdevelopment' and 'development' were used for the first time to imply 'economic backwardness'.[32] Point Four was a facade, according to Rist, to justify United States intervention policy in developing countries.[33]but it changed the way idea of development was perceived. Before Point Four, word development was something natural,

[26] Hettne, pg 69
[27] Hettne, pg 69
[28] Knutsson, pg 9
[29] Hettne, pg 70
[30] http://www.presidency.ucsb.edu/ws/?pid=13282
[31] Rist, pg 72
[32] Rist, pg 73
[33] Rist, pg 75-76

organic and underdevelopment employed lack of development. Point Four inverted these meanings: underdevelopment was a natural occurrence and development was a natural goal.[34] Basic problem plaguing Point Four, Rist notes, is assumption that underdevelopment in countries of the South is natural state and through growth and aid, they too can recover.[35] Point Four, thus, ignores historical reasons for underdevelopment.

Arguments and policies described in Point Four continue to dominate developmental literature. Idea of Productivity is central in Point Four. Truman asked people to move outside the dual realm of capitalism and communism and into the 'realm of productivity' where abundance will turn into happiness. GDP, thus, became the indicator for success. More than half a century later, aim of sustainable development is to 'encourage programmes on sustainable consumption and Production'.[36] Though many other measurement tools have been created in last decades, they all 'complement Gross Domestic Product'[37] and do not replace it.

Truman's Point Four wheeled major influence throughout the First Epoch of Development. Aid became, in aftermath of WWII and midst of Cold War, an important tool in addressing poverty in developing countries and security in developed countries. Purpose of Aid has metamorphosed into different faces but charm and effectiveness remains true to Truman's Point Four. In the same spirit, Sustainable Development Goals calls for 'increase in Aid for trade support'[38] and 'support economic development and human well-being'. [39]

Events following Truman's Point Four, Korean War (1950-1953); Stalin death (1953); Geneva Accords (1956); Algerian War of Independence, Suez Operations, Soviet Intervention in Hungary,[40] made Third World an ideological battleground.[41] The lure of modernization became the key agenda for discussion. Thus, 60s became 'heyday of modernization and developmental optimism'[42] and United Nations called 1960s the 'First Developmental Decade'.

The Mainstream-Counterpoint-Dialectic remains same through the First Epoch of Development. In the First Epoch of Development everything is simple. The problem is Backwardness (Gerschenkron; Hettne; Knutsson). The solution is Modernization. Idea of modernization, presented initially through Truman's Fourth Point, evolved during Cold War. WW Rostow's 'Non-Communist Manifesto' gave a utopian goal to all the countries of the world: 'Mass Consumption'.

Whether you are 'First World', the Capitalists, or 'Second World', the Socialists or 'Third World', everyone else, Modernization was the solution to every problem: a developmental panacea. The differences between all the arguments was about 'how to achieve' not 'what to achieve'. Every country wanted modernization but every country had a different set of strategies.

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[34] Rist, pg 73
[35] Rist pg 79
[36] Transforming Our World 28a(2)
[37] Transforming Our World 48c
[38] Transforming Our World Goal 8a
[39] Transform Our World Goal 9.1
[40] Rist, pg 80
[41] Rist 81-82
[42] Knutsson, pg 12

Until Dudley Seers' Limits to special case, there was no alternative idea to modernization. Dudley Seers questioned economic thought which was pervading university system. Seers suggested that Paul Samuelson's seminal textbook '*Economics*' should add a qualifier, Economics of United States, because the book only deals with, or assumes the case of US to be the general condition of the world.[43] At the same time, the Marxist texts were also entirely useless if one had to understand 'backward countries'. Because Marxist text like *Political Economy* prepared by Academy of Sciences of the Soviet Union, according to Seers, rely rigid tenets of Marxism these texts were useless in explaining a country like Ghana.[44] Seers protested against looking at world with the same eyes and suggested that 'universities of the developed countries, at least, should be based on the local models, as they are at present.'[45] In the countries of the North, this was the first real effort to the highlight the importance of differences in developing countries.

During the seventies- according to UN, 'Second Development decade'- there were elements within and outside UN that questioned the modernization goal. But there was no major change in developmental thinking. In 1972, United Nations held conference on 'Human Environment' which for the first time drew mainstream attention to 'pollution, exhaustion of natural resources, desertification.'[46] This was the first environmental concern that emerged in any developmental discourse. In the same year, commissioned by Club of Rome and funded by Volkswagen Foundation, Limits to Growth predicted that world will collapse if resources were used at current rate. Limits to Growth was criticised but the report had a profound effect on developmental thinking. In 2014, University of Melbourne found that even after forty years Limits to Growth predictions are 'accurate'.[47]

Another idea that laid groundwork for future developmental thinking was John Rawls' Theory of Justice. This book didn't explicitly question the modernization goal but, questioned the core idea of utilitarianism in economics and political philosophy. Ultimate aim, according to Utilitarianism, is to provide 'greatest good to greatest number of people',[48] which is basic tenet of modernization, productivity and economic growth. Rawls, in Theory of Justice, argued that political philosophy should not be based on goods and growth but on principles of justice. This critique of modernization affected not only philosophy, economics but also developmental thinking. Amartya Sen's Capability Approach heavily draws on Rawlsian principles of Justice.

4b HISTORICAL BLOC- STATE HEGEMONY

In 1950s, 60s and 70s there is a clear hegemony of state in the historical bloc which only breaks in the mid 1970s resulting in a real 'discursive change'.[49] Keynesianism was economic ideology which led to 'great compromise' between national regulation and free-trade. These were the golden period of modernization.[50] State is clearly main agent of change in First

[43] Seers, The Limitations of Special case, 1963, pg 88
[44] Seers, pg 93
[45] Seers, pg 98
[46] Rist, 2008, 141
[47] http://www.theguardian.com/commentisfree/2014/sep/02/limits-to-growth-was-right-new-research-shows-were-nearing-collapse
[48] http://harvardpress.typepad.com/hup_publicity/2013/04/john-rawls-a-theory-of-justice-1971.html
[49] Hettne, pg 85
[50] Hettne, pg 70

Epoch of Development.[51] State controlled and governed the markets. Civil Society was dormant until 1968. The student revolution of 1968 rattled capitalist and communist regimes. This was the beginning of the first movement within historical bloc when civil society disrupted hegemony of the state. Market, the third component of historical bloc, will make its move immediately after the Oil Crisis.

In 1974, as a protest to western support for Israel against Egypt, Arab Oil producers imposed an embargo which led to the rise in price per barrel from $3 to $12. This price rise brought inflation in transport and food, but the major impact was borne by manufacturing companies. The Arabs put the 'petro-dollars'- i.e. extra income due to increase in Oil prices-back in western banks, which were lending the money, quite generously, to third world countries. At the same time, western countries were combatting inflation by raising interest rates. The interest rate raised to such a level that borrower, the 'third world countries' were unable to keep up payments.[52] To combat these shocks, United States, instead of raising taxes, issued money believing that money would come to US. This line of reasoning was correct but only if US industry was competitive. It was not. And investors were willing to bet on emerging industrial powers. Thus, US could 'no longer guarantee the dollar-gold standard', finalizing the demise of Bretton Woods.[53] The nature of Oil crisis, and then the debt crisis, showed the ineffectiveness of state as the main actor of change. The 'golden period' of western had ended and, with it, hegemony of the state.

4c CONCLUSION

The idea of development in the First Epoch of development was simple: Some countries are backward; they need to modernize through aid or industrialization. The purpose of development was 'classless society' or 'mass consumption'. Modernization remained the mainstream idea. There was no question about what to achieve, but only about how to achieve. There were debates about how to bring Economic Growth. The golden rule: Economic Growth and Productivity. State was the only agent in the historical bloc that could bring about modernization. This changed in the Second Epoch of Development.

5. SECOND EPOCH OF DEVELOPMENT 1975-2000

David Harvey predicts that the period 1978-1980 will be regarded by 'future historians' as 'revolutionary turning point in the world's social economic history'.[54] Deng Xiaoping, in 1978, shifts China towards liberalization.

5a HISTORICAL BLOC-MARKET AND STATE

In May 1979, Margaret Thatcher becomes Prime Minister of Britain. She campaigns against monopoly of trade unions and against rising inflation. The same year, Monetary Policy in Unites States changes under Paul Volcker. The fight under inflation, rest may be damned, becomes the official mantra. In 1980, Ronald Reagan becomes President of United States.

[51] Hettne, pg 2
[52] Rist, pg 172
[53] Knutsson, pg 14
[54] Harvey, A Brief History of Neoliberalism, 2005, pg 1

Harvey makes the case that changes of such magnitude do not come by accident. It is not task of this paper to analyze Harvey's thesis, however, his emphasis on importance of this period is correct related to developmental thinking and the nature of historical bloc.

During and after this period, Keynesianism was dead and with it, role of the state changed. It was end of 'great compromise' and beginning of 'Washington Consensus'.[55] The Nobel Laureates in Economics from the mid 70s were Hayek, Friedman, Meade and Ohlin. It was the rise of the Market in the historical bloc. Market gained real bloc hegemony in 1980s with state having a new function. State was not harbinger of policy but, as argued in Nozick's *Anarchy, State and Utopia*, function of the state was akin to a 'night watchmen' that protects people's private property.[56] In developmental thinking, state would create conditions for markets to flourish. State, therefore, retained an important function in the historical bloc- to create conditions for efficient markets. Civil society still remained dormant

Despite such importance, Market couldn't retain hegemony in the historical bloc. One reason is that role of state was not nullified but modified. State didn't become redundant but 'facilitator of market'.[57] Second, state cannot just wither away because measurement tools, policies, rules and laws are designed in the context of state. Though, globalization as an idea started in the Second Epoch of Development,[58] the idea of truly globalized world has not materialized until today. There is no freedom of movement for labour, even though capital is free to move. Therefore states have continued to play important role even when there was ideological pressure to reduce its role.

Market friendly policies of 1980s were such failure that it was dubbed as 'lost decade'. The reason for this failure is summed by Rist (2008) in 'two words: Structural Adjustments'.[59] Harvey calls 1980s as 'beginning the long era of structural adjustments'.[60] The argument for structural adjustment was based on the assumption that once political and bureaucratic red-tapes disappear, market will stabilize. Hettne notes that market friendly political framework is not a new idea. But as Karl Polanyi noted, when market framework becomes a priority to generate economic growth, then, social justice is ignored.[61] Structural adjustments, nonetheless, are not universally derided.

Dollar and Svensson (2000) argue that structural adjustment failed not because of donor policy but due to recipients' political-economic forces. For example, Zambia received almost $212million which Operations Evaluation Department, and other bilateral donors, concluded that three out four loans were failure. Dollar and Svensson suggest that in the hindsight it should have been obvious because Zambia didn't have 'conditions conducive to reform'.[62] Whereas Dollar and Svensson see political instability in the developing countries as main reason for the failure of structural adjustment, Harvey suggests the function of structural adjustment programmes is to control crisis in a 'way that permit accumulation by dispossession to occur without sparking a general collapse or popular revolt'.[63] The failure of

[55] Hettne, pg 91
[56] Robert Nozick, Anarchy,State and Utopia, 1974
[57] Knutsson, pg 23
[58] Hettne, 2008, pg 85
[59] Rist, 171
[60] Harvey pg 2
[61] Hettne, pg 93
[62] David Dollar and Jakob Svensson, What Explains the Success or Failure of Structural Adjustment Programmes, 2000,894-917
[63] Harvey, pg 163

structural adjustment programs, Harvey notes, can be seen in the anti IMF 'protest in Mexico City, Johannesburg, Buenos Aires and other major cities in the wake of structural adjustment'.[64] Whatever the reasons, structural adjustments— it is certain— proved disastrous for developing countries. The decade of the market, which was categorized as 'Third Developmental Decade' by UN, turned to be nightmare and, though market didn't lose its significance, market lost its hegemony in the historical bloc.

End of Market hegemony is mirrored, in the Second Epoch of Development, by rise of civil society. Political movements against WTO in 1998 in Geneva and then in Seattle in 1999 and then against Davos in 2001 signal the rise of civil society within the historical bloc.

5b DEVELOPMENTAL THINKING

If Mainstream theories of economic growth and productivity defined the First Epoch of Development, then Counterpoints sketched Second Epoch. United Nations' report *What Now? Another Development* was the first Counterpoint which questioned the assumption of continuous economic growth. The 'modern industrial development',[65] according to the report, 'was unsustainable'. Another Development provided a serious 'alternative' to modernization paradigm because it was a) territorial rather than functional b) cultural paradigm rather than standardized modernization and c) focussed on ecological sustainability rather than growth (Hettne, 1995, pg 199).[66]

In contrast to Mainstream theory of modernization, Alternative Development based its foundation on 'need oriented, endogenous, self-reliant, and ecologically sound' strategies. Hettne suggests that both Another Development and modernization are utopian. Mainstream is utopian because of continuous belief in infinite growth and development in a world of scarcity. Another Development is utopian because people have faith in the theory despite no political backing.[67] Knutsson suggests that with addition of Another Development there was 'widening of potential repertoire' i.e there were now more policy options available to developmental theorists.[68]

Here, I would point out that despite much similarity between ideas of Another Development and present understanding of sustainable development, there is one major difference. Another Development didn't focus on economic growth but questioned its core whereas Sustainable Development puts economic growth as fundamental to environmental improvement in the long run.

Basic Need Approach (BNA) was another important counterpoint. BNA shifted the focus away from growth and towards equity (Farooq, pg 363).[69] In 1976, in order to rectify past developmental failures, and to deal with 'widespread pessimism' (Streeten and Burki, pg 411),[70] International Labour Organization (ILO) suggested an approach that gave new

[64] Harvey, pg 185
[65] Knutsson pg 18
[66] Knutsson, pg 19
[67] Knutsson, pg 19
[68] Knutsson, pg 21
[69] Mohammad Omar Farooq, Basic Needs Approach, 1988, pp. 363-370
[70] Streeten and Burki, Basic Needs: Some Issues, 1978. pp 411-421

'meaning to development' which was beyond economic growth.[71] Soon, the World Bank noticed the BNA approach. Norman L Hicks suggested, with a warning of caution, that 1) "countries making substantial progress in meeting basic needs do not have substantially lower GNP growth rates and 2) the attainment of a higher level of basic needs satisfaction appears to lead to higher growth rates in the future" (Hicks pg992).[72] Hicks suggested that BNA and growth necessarily don't need to be mutually exclusive and countries can run two simultaneous policies, one for BNA and other for growth and investment. Moreover, there is no negative correlation, argues Hicks, between investment in BNA and Growth. What he found, contrary to what many would think possible at that time, is that there is long term positive correlation between BNA and growth. Thus, Hicks gave an instrumental reason for targeting Basic Needs. Basic Needs Approach was quickly adopted by World Bank and other developmental. BNA started as a Counterpoint but quickly became Mainstream.

Counterpoints like Basic Needs Approach and Another Development in 70s extended the debate but it wasn't until 1980s when the economic assumptions behind developmental thinking were seriously questioned. If First Epoch of Development is Truman's Point Four then Second Epoch of Development is works of Amartya Sen.

In his 1982 essay Poverty, and Famines: An Essay on Entitlement and Deprivation, Sen argued that Bengal Famine occurred due to lack of entitlement and not due to decline in food productivity. Sen showed that before and during famine, food productivity was on the rise. It was not lack of availability of food but lack of accessibility of food that caused famine. Though Sen's entitlement approach has been criticized (De waal 1990; Rangaswami 1985; Mitra 1982), it, nonetheless, questioned the very basic assumptions of Mainstream developmental thinking.[73]

Sen's Capability Approach is another critique of productivity and economic growth. What is the importance of having a book, if one cannot read it, asks Sen. Books are resources. Mainstream economic thinking has argued to produce more and more books. Sen points out that it is important for the person to be 'capable' of reading the book to get any satisfaction out of it. Just by merely having a book will not generate utility or satisfaction. Reading is 'functionality'. A person's life should not be measured by how many books that person has but how many functioning that person can choose. This is capability approach. The theory is broad and, at times, vague. But what it lacks in clarity, it gains in plurality. The focus, thus, should not be on GDP but what can one do with GDP.

Sen's most influential book Development as Freedom gave most liberal non-neoliberal argument. Sen argued for a welfare state but one that does not limit forces of the market. Focus the policies not to any one form of development but to a holistic function of development. In Sen's words-Freedom is not only the goal of development but it also a tool through which development can be achieved. Most insightful anecdote in the book is the comparison between people in Kerala, India with African Americans. Sen showed that in Kerala, region of a 'developing country', people had better access to health than some African Americans in USA. Arguing that sometimes where it matters, GDP and economic growth doesn't benefit everyone.

In 1991, Mehboob ul Haq, Pakistani Economist, commissioned first Human Development Report. This report was heavily influenced by Sen's work. This report pointed towards the

[71] Farooq, pg 364
[72] Norman L. Hicks, Growth vs basic needs: Is there a trade-off?, 1979, Pages 985-994
[73] P. Nayak, Understanding the entitlement approach to famine, 2000, pp 60-65

high inequality in the world: top 20% of the people have more than 82% of the world's wealth.[74] Human Development Report created Human Development Index (HDI) as an alternative to measuring progress. This was the first serious alternative to GDP. HDI measures life expectancy, education and health of the country as well as GDP to give a broader understanding of the situation. Thus, HDI provides a measurement of development that is more than Economic growth.

Harvey calls Sen's Development as Freedom 'by far the most sensitive contribution to the discussion over recent years', but Harvey questions why Sen 'wraps up important social and political rights in the mantle of free market interactions'.[75] Though Sen questioned the very basic assumptions of economic growth and productivity, he didn't nullify importance of growth. It is no surprise that Sen's work was quickly co-opted for it was not too far away from any mainstream thinking. Sen grants equal importance to state as well as to the market. Incidentally, Sen's argument mirrors the situation in historical bloc except one important difference. Whereas, Civil Society is dormant in historical bloc, Sen's work have always emphasized on the important role for the individual.

The final counterpoint, in the Second Epoch of Development, against the mainstream theory of economic growth, was ecological degradation. In 1983, United Nations General Assembly asked Secretary General to form The World Commission for Environment and Development. Five years later, in 1987, *Our Common Future*, now famously known as *Brundtland Report*, was published.[76] Though the idea of sustainable development had earlier been introduced through The World Conservation Strategy (Bjorneloo, 2007), this was the first time that term sustainable development gained institutional existence.[77] We will see that all the ideas present in Sustainable Developmental Goals have already been established and matured, first with Alternative Development and now, with Brundtland Report.

The report suggested that sustainable development is to 'meet the needs of the present without compromising the ability of future generation to meet their needs'.[78] Hettne, however, argues that such definition of sustainable development is about intergenerational justice rather than nature of development.[79] It is still the definition of Sustainable Development. The definition and objectives given in Brundtland Report are the basic definitions that forge Sustainable Development Goals 2016. Knutsson, therefore, suggests that Our Common Future is 'landmark and catalyst of sustainable development'.[80] The dangers of ecological damage were 'long seen as regrettable but necessary cost' of development.[81] But Brundtland Report questioned this assumption. At the same time, Brundtland Report— like Amartya Sen's work— was not too radical. In Limits to Growth or previous environmental conferences, ecological degradation had a negative narrative. But with Brundtland Report, and Earth Summit in 1991, words such as sustainable growth and sustainable development were corporatized.[82]

[74] Knutsson pg 29
[75] Harvey, pg 184
[76] Knutsson pg 23-24
[77] Knutsson, pg 24
[78] Knutsson, pg 24
[79] Hettne, 120
[80] Knutsson, pg 24-25
[81] Rist pg xii
[82] Globalization and Development, pg 316

One cannot ignore the importance of Brundtland Report. Brundtland Report brought environmental debate on the mainstream table, to say the least. The Brundtland Report was, according to Gro Harlem Brundtland— Chairperson of the Commission, 'central document of development and a reference point for further international cooperation'.[83] This report was a start of the conversation that emphasized for action at global level rather than state level. Brundtland in her memoir, Madam President, recalls that in 1992 Harvard Lecture she made the case against nation states being the primary agents of change. She writes that 'nation states were too small to solve problems that were essentially of a regional or international nature. If we continue to foster the illusion that countries could operate independently of one another, then we risked postponing decisions that could only be made effective by countries reaching decisions and acting together'.[84] The report recommended strategies at national and international levels to counter economic, social and ecological problems but focus was now shifting to global action and global policy.[85] This was the start of the conferences like, Environmental conference in Rio 1992 which suggested drastic 'change in living'.[86] Similar rhetoric was repeated at in 1997 at Kyoto Protocol that there is urgent need to reduce greenhouse gas emission, where USA was a notable exception to this treaty.[87]

By the end of Second Epoch of Development, developmental problems included environmental degradation but also issues related to women, children, unemployed, sick, etc. All marginalized groups were also brought under developmental framework. These movements resulted in UN conference on Education in 1991, UN conference on Human Rights 1993, UN conference on Women 1995.[88] Idea of Good Governance entered into vogue.[89] Development that only meant modernization became non-existent and naive.

Even the postmodernists were involved in developmental debate. Whereas Another Development, Sen's work, Brundtland Report provided somewhat alternative paradigms in their critiques, Post Developmentalist thinkers provided critique without any real alternative.[90] For Postmodernists, like Rist, any change in developmental thinking only corresponded to old wine new bottle.[91]

5c CONCLUSION

Knutsson inspects this period and concludes that there is 'widening of potential repertoire'.[92] It is indeed the case. In the Second Epoch of Development many new ideas came into developmental thinking. Environmental limits, Human Development, Capability Approach, Sustainable Development and Another Development. All of which, in one form or another, questioned the monotonous view espoused in the First Epoch i.e. Development equals Economic Growth. Even in the historical bloc, there were role reversals. First, state lost its hegemony to the market but market forces couldn't really fortify hegemony in historical bloc. Though, in Economics, Keynesianism was superseded by neoclassical thinking and market

[83] Gro Harlem Brundtland, Madam Prime Minister, 2002,pg 336
[84] Madam Prime Minister pg 340
[85] It is interesting to note that objective of sustainable development goals is to deal with economic, social and environmental problems.
[86] Knutsson pg 29
[87] Knutsson pg 29
[88] Knutsson pg 31
[89] Knutsson pg 30
[90] Knutsson pg 27-28
[91] Knutsson pg 31
[92] Knutsson, pg 28

gained divine importance. In developmental thinking, counter arguments and failure of structural adjustments damaged market hegemony. By the end of the epoch, civil society started participating in movements and demonstrations transpired against degradation of environment.

The Second Epoch of Development, despite all the various counterpoints, didn't question the theory of economic growth. On the contrary— despite 'new wars', failed states, humanitarian intervention, Mainstream economics remained untarnished. Faith in unregulated market economy enabled some commentators to suggest that days of business cycle are over.[93] This faith in markets was not questioned until economic crisis in East Asia.

East Asian Crisis started with speculative property market. To combat it, Thailand devalued its currency but couldn't contain the crisis from affecting Indonesia, Malaysia, and Philippines. Hong Kong, Taiwan, Singapore and South Korea were next to feel effects of crisis. Countries such as Estonia, Russia, Brazil and Argentina were not even immune to it.[94] The standard mainstream explanation for crisis was 'state intervention' and 'crony capitalism'.[95] The counter explanation was 'no regulation'.[96] But the real insight from this crisis was markets are not efficient enough and states are not powerful enough to resolve economic crisis. There was a need for a new paradigm.

6. THIRD EPOCH OF DEVELOPMENT 2000-Present

Knutsson suggests that post 2000 developmental discourse differs from earlier developmental thinking in two ways a) post 2000 discourse is complex in nature and b) there is a realization and recognition of this complexity.[97] Post 2000 discourse is complex. It is diverse. And, yes, there is recognition that it is complex. The problem is that post 2000 discourse does not offer any new ideas. There is no 'widening of potential repertoire'. Developmental thinking in the Third Epoch of Development is akin to 'Developmental Thali'. Thali is a combination of various dishes served on a single plate. The term 'Thali' has been used before to define Indian democracy. Here, I avoid any value judgment and suggest that Third Epoch of Development is a Thali where various, often contradictory, policies are presented on a single plate. The first plate was Millennium Development Goals.

6a DEVELOPMENTAL THALI: MDGs

The Third Epoch of Development starts with a very positive and optimistic strategy. United Nations' report, *We the People*, hailed 'the arrival of the new millennium' as 'an occasion for celebration and reflection' and set goals for next fifteen years.[98] *We the People* report termed these goals and targets, Millennium Developmental Goals (MDGs). In contrast to previous UN developmental commitments, MDGs were 'time bound and quantified targets for addressing poverty in its many dimensions-income poverty, hunger, disease, lack of adequate

[93] http://www.economist.com/node/146279
[94] Harvey, pg 96
[95] Harvey, pg 97
[96] Paul Krugman, What Happened to Asia, 1998
[97] Knutsson, pg 33-34
[98] http://www.unmillenniumproject.org/documents/wethepeople.pdf

shelter, and exclusion-while promoting gender equality, education, and environmental sustainability.' MDGs include 'basic human rights-the rights of each person on the planet to health, education, shelter, and security.[99]MDGs drew boundary of developmental strategies and parameters of developmental thinking.[100]

Each goal will have finite number of targets and specific indicators to measure against. First six goals were specifically targeted at developing countries and last two concerned the whole world. Interestingly, these two goals are least definite among all eight. For example, Goal 8: Develop a Global Partnership for Development included indicators of debt relief and telephone lines. MDGs, without a doubt, were different from any other United Nations commitments. It was, as Hettne suggests, 'a high point of international law and multilateralism' because more than 150 countries participated.[101] But it will be wrong to suggest that MDGs introduced new ideas. In fact, each of the goals of MDGs can be seen as an extension of either mainstream or counterpoints of previous epochs. Then, what are MDGs?

At first, MDGs appear a dialectical result of mainstream and counterpoint. But it is dialectic? Truman's Point Four still remains intact i.e importance of economic growth does not relent. Economic Growth remains the key indicators of development in MDGs. Health has functional value since it 'stimulates economic growth while reducing poverty and income inequality'.[102] Freedoms from want and human rights also have a functional value. MDGs also targets health, education, life span etc. Each and every policy introduced in the past in neatly present. It, therefore, cannot be a dialectical result because there is nothing new. What is new is the fact that all these policies are presented in one framework. Thus, MDGs are a special type of compromise where various ideas of developmental thinking are presented together under a single framework. MDGs are an example of 'Developmental Thali'.

MDGs give equal importance to all the agents in historical bloc. In support of the market, MDGs deride trade barriers as the reason for declining 'African productivity'.[103] In support of civil society, MDGs emphasize that since 'states are principal perpetrators of violence against the very citizens', 'centrality of international humanitarian and human rights law' is important. And the UN Millennium Declaration 'recognizes that, in addition to our separate responsibilities to our individual societies, we have a collective responsibility to uphold the principle of human dignity, equality, and equity at the global level. At the same time, in support for state, MDGs point out that states have a duty therefore to all the world's people, especially the most vulnerable and, in particular, the children of the world, to whom the future belongs.'[104] Thus, states are acknowledged to be principal agents though superseded by the moral support for the global civil society.

To mark mid-way point of MDGs, which was incidentally also the first year of financial crisis, World Bank published Global Monitoring Report.[105]Global Monitoring Report acknowledged that mid-point analysis of MDGs is not optimistic because there are 'serious shortfalls in fighting hunger and malnutrition' even though poverty goal 'is likely to be met at

[99] http://www.unmillenniumproject.org/goals/
[100] http://www.unmillenniumproject.org/goals/index.htm
[101] Hettne, pg 121
[102] We The People, 2000, pg 26
[103] We The People, pg 31
[104] UN Millennium Declaration 55/2 http://www.unmillenniumproject.org/documents/ares552e.pdf
[105] Global Monitoring Report, MDGs and Environment, 2008,

the global level.'[106] The report attributes the accomplishment of achieving the poverty goal to 'remarkable surge in global economic growth over the past decade'. It is now clear that it wasn't 'remarkable surge in global economic growth' but remarkable economic growth in China that reduced the amount of people living in poverty from 689 million to 250 million by 2011.[107]

In order to achieve all the MDGs, the report proposes 'an agenda for inclusive and sustainable development'. To achieve growth, policy may vary in each country; so long as 'essentials' are satisfied. According to the report, 'sound macroeconomic policies, a conducive private investment climate, including access to energy and other key infrastructure and good governance' are essentials for any economy.[108] Global Monitoring Report also provides remedy for the financial crisis by suggesting 'stronger prudential supervision to put the financial system on a firmer footing'. These essential are not new but collection of previous developmental ideas.

The report highlights that 'progress towards the human developmental goals' is priority and that 'we must make environmental sustainability into core developmental work' because it is critical for 'sustainable growth'. Thus, sustainability of environment supports the sustainability of economy. From Climate change, 'poor countries will suffer the most' and 'for them (the poor countries) the best way to adapt is to develop— by diversifying their economies, strengthening infrastructure, and developing health systems.[109] Aid is important, but 'need to catalyze and leverage more private capital in support for development'. Trade is fundamental for 'poor countries' who can take advantage of trade opportunities. There is also a call for international institutions to 'tailor' policies for country specific but also expand agenda by including 'climate change'.

The report is, after MDGs, first grand gesture from the mainstream to combine aid, climate change, human development, trade liberalization and sustainable development into one developmental framework. GMR weaves all counterpoints into policy without exempting any of the earlier ideas such as growth and productivity. Instead of a true dialectical change, Global Monitoring Report is another example of 'Developmental Thali'.

6b SDGs: ANOTHER DEVELOPMENTAL THALI

MDG was an 'important framework' but after fifteen years 'some goals remain off track'. Therefore, Sustainable Development Goals aims to realize the remaining MDGs and more.[110] According the Charter, Sustainable Development Goals are 'New Agenda' and are 'far beyond Millennium Development Goals'.[111] The SDGs are concerned with five Ps: People, Planet, Prosperity, Peace and Partnership. The objective is to 'strengthen universal peace' and eradicate 'poverty in all forms and dimensions'. The parts of sustainable development are 'economic, social and environmental' which are 'integrated and indivisible and balance' each other. Sustainable Development Goals includes economic growth, universal education, universal health coverage, human development, capability approach, sustainable environment, trade, support for weak and vulnerable, women empowerment, technological support for

[106] GMR: 2008: xi
[107] http://news.xinhuanet.com/english/2015-09/26/c_134661386.htm
[108] GMR: 2008 xi-xii
[109] GMR xii
[110] Transforming Our World 16
[111] Transforming Our World 17-18

developing countries. Each and every idea of developmental thinking is included from the past.

On inspecting the document 'Transforming Our World', it is clear that Sustainable Development Goals are collection of various developmental ideas. In the past, some ideas may have appeared contradictory— like environment and economic growth, or productivity and human development. But with SDGs, all ideas are complementary and not contradictory. Like a Thali, various different, and often contradictory, developmental ideas are presented together to be implemented together. It is this 'Developmental Thali' that is 'accepted by all countries and applicable to all'[112] and is 'win-win co-operation'.[113]

Knutsson's thesis that developmental thinking proceeds in a dialectical manner and thus widens 'potential repertoire' does not apply to Third Epoch of Development. There isn't any increase in developmental thinking. The most important change is that many developmental ideas have gained mainstream institutional support but in so far as developmental thinking is concerned, nothing new appeared on the developmental scene.

In a world that this charter 'envisages' , 'democracy, good governance….rule of law as well as enabling environment' are 'essential for sustainable development', so are 'inclusive economic growth, social development'.[114] International trade is 'engine for growth' as well as engine for 'sustainable development'.[115] To the point that even sport is considered 'enabler of sustainable development'.[116] Opening remarks by Dr Abdalla Hamdok, Deputy Executive Secretary, at African Regional Forum organized by UN Economic Commission for Africa clearly show this 'Developmental Thali'. The baton that we should pass, according to Dr Hamdok, to the future generation includes environment as well as 'growth and prosperity' because they 'key fundamentals to "Africa We Want" and woven through the common threat of sustainable development'.[117]

Sustainable Developmental Goals is not a 'new agenda' as the report, *Transforming Our World*, suggests. It is surely 'far beyond' MDGs in its lexical utterance of goals and targets. It is much broader in its reach but it includes all the possible options even the contradictory ones. It is a special type of dialectics not the normal one that Hettne and others have suggested.

Sustainable Development Goals, like MDGs before it, emphasizes on the importance of all three agents to work together to form 'win-win' cooperation. State remains the most powerful identity. The charter is signed by 'we, the Head of states'[118] and 'every state has full permanent sovereignty over all its wealth, natural resources and economics activity'.[119] Market, private sector, has an important 'role'[120] as a 'major driver of productivity'[121] and

[112] Transforming Our World point 5
[113] Transforming Our World, point 18b
[114] Transforming Our World point 9c
[115] Transforming Our World 68
[116] Transforming Our World 37
[117] http://www.uneca.org/sites/default/files/uploaded-documents/ACPC/ARFSD2016/des_speech-afrsd-18_may-checked_against_delivery.pdf
[118] Transforming Our World, point 1
[119] Transforming Our World point 18c
[120] Transforming Our World point 41
[121] Transforming Our World 67

their 'contributions', along with contributions of civil society are mentioned.[122] Civil society remains integral part of building the 'future for all people' and 'creating a better world'.

There is one difference with MDGs and SDGs, however. SDGs emphasize on regular reviews at sub national, national, regional and global levels. Regional level, reviews will be 'useful opportunity for peer learning'. At global level, High Level Political Forum (HLPF) will conduct reviews of the policies. This is new, surely but even this new addition is severely limited. The reviews are voluntary and states remain central agent to the review process. Even at the global level, reviews will be state-led[123] and almost all reviews will be voluntary.

Despite the 'unwavering commitment to achieve this agenda', there is a problem with voluntary reviews. So far[124] only twenty two countries have submitted voluntary reviews. There are reviews from multi-stakeholder partnerships but there are no voluntary input from Major groups and other stakeholders. Similarly, the criticism lauded upon Paris Agreement, signed in April 2016, is that agreement is 'no action, just promises'.[125]

For Developmental thinking, it is important to understand discourse disseminating from United Nations. The reason is that so far, in the Third Epoch, the United Nations with its MDGs and SDGs has become the pioneer of developing discourse. Just like US state set the developmental discourse in the first epoch of development, and counterpoint belonged to everyone working with and against mainstream policy in the second epoch, the third epoch is dominated by discourse emanating from United Nations.

6c HISTORICAL BLOC: CIVIL SOCIETY FIGHTS BACK

Two important events define Third Epoch of Development. First, a year after MDGs were approved, on 11th September 2001, New York became target of terrorism. The consequence of this event will define the first part of Third Epoch of Development. Political discourse, in the aftermath of 9/11, mutated from humanitarian intervention to 'War on Terrorism'.[126] There is enough literature on 9/11 and its effects on global political policy so it is not the subject I will pursue in the paper but I will talk about two implications that affected developmental thinking.

First and Foremost, global community protested against invasion of Iraq. According to Gallup Polls, international community was virtually against the war against Afghanistan and Iraq. Patrick E Tyler writing, in The New York Times, suggested that these demonstrations were a proof of 'new power in the streets' i.e the civil society.[127] The second important implication was that security became an important developmental issue just like in the days of cold war.[128].

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[122] Transforming Our World 79
[123] Transforming Our World, 84a
[124] Until 27th of May 2016
[125] http://www.theguardian.com/environment/2015/dec/12/james-hansen-climate-change-paris-talks-fraud
[126] Hettne, pg 99
[127] http://www.nytimes.com/2003/02/17/world/threats-and-responses-news-analysis-a-new-power-in-the-streets.html
[128] Hettne, pg 77

Second event that defined Third Epoch is the 2007 financial crisis. The crisis started with US housing bubble and then credit crunch in Europe which led to western states making commitments to save defaulting banks. This commitment slid crisis into the real economy i.e fall in production and increase in unemployment.[129] Loss of faith in free market followed loss of faith in politics. The impact of financial crisis was not only limited to western countries. As implication of 9/11 and Afghanistan and Iraq War were global, so were the implications of financial crisis because investors from all around the world didn't suspect of having 'toxic' mortgage-backed securities.[130]

Almost all countries were affected but not equally.[131] Exports in East Asia fell about 20%[132] because East Asian countries relied heavily on US markets.[133] Germany and Brazil— raw material producers— also felt the crunch because prices plummeted in the second half of 2008.[134] Russia, Venezuela, and Gulf states, oil producing countries, suffered as prices fell from $150 in summer of 2008 to $40 a barrel in few months.[135] The financial crisis also affected those in poor countries. The oil crisis in Gulf States meant that projects couldn't continue and many migrant workers were 'sent home'.[136] Similarly, in countries like Mexico, Ecuador, Haiti and Kerala in India, remittances sharply fell resulting in decrease in income, malnutrition, and starvation.[137]

Like the Oil Crisis of 1970s kneeled Keynesianism, Financial Crisis of 2008 started discussion among politicians, academics and scholars examining the basic assumptions of neoclassical economics. It is important to note that, while developmental thinking produced many counterpoints to mainstream developmental thinking; mainstream economics remained unchallenged until this financial collapse. But after the crisis, hundreds of books were published to explain the crisis. Gary Becker,[138] Akerlof and Shiller,[139] provided mainstream view of failure of market. Harvey,[140] Graeber,[141] Chomsky,[142] Zizek gave a radical view on the inherent flaws of the system. The general conclusion from these debates was that things cannot continue like this. It would suffice to say here that civil society, again, had an important role to play in these debates.

People lost faith in state as well as market in this decade. Civil society, in these times, competed to form hegemony— for the first time since WWII— in the historical bloc. On 17th December 2010, Tarek al-Tayeb Bouazizi set himself on fire as a response to harassment by police officers in Sidi Bouzid, Tunisia.[143] The protests spread to Bahrain, Egypt, Jordan,

[129] Hettne, 106
[130] Harvey, pg 4
[131] Hettne, 106
[132] Harvey, pg 6
[133] Harvey, pg 3
[134] Harvey, pg37
[135] Harvey, pg 38
[136] Harvey, pg 38
[137] Harvey, pg 38
[138] Gary Becker and Richard Posner, Uncommon Sense, 2009
[139] George Akerlof and Robert Shiller, Animal Spirits, 2009
[140] David Harvey, Enigma of Capital, 2010
[141] David Greaber, Debt, 2011
[142] Noam Chomsky, How the World Works, 2011
[143] Jason Browniee et.al The Arab Spring: Pathways of Repression and Reform, 2015, Pg 10

Libya, Syria, Yemen, Algeria, Mauritania, Morocco, Sudan and Gulf States. More than 90,000 people died during Arab Spring due to suppression of these protests.[144]

It was, according to many commentators, a change in Arab political sphere. However, few years later, out of fourteen countries, these protests only dethroned four dictators.[145] Hence, the results of the Arab Spring haven't matched as they were once predicted and demonstrators have faced many challenges.[146] The protests failed to produce the desired results as repression continued. Saudi Arabia, for example, used carrot and stick to counter the protests by increasing subsidies for its citizens and arresting non-sectarian activities.[147] Arab Spring, despite its results, 'has had a significant psychological effect on large parts of the ordinary populations in the Arab world'.[148]

The global north, or the developed countries, also went through a 'significant psychological effects' after the financial crisis. A week after the tenth anniversary of 9/11, on 17th September 2011, Occupy Wall Street began. Michael Moore, the documentary film-maker, claimed that 'I have never seen a political or a social movement catch fire this fast'.[149] Just like Arab Spring, Occupy movement evolved and spread globally. In fact, many commentators have suggested that Occupy Wall Street and Arab Spring were highly co-related. [150] Occupy Wall Street is a 'palimpsest', according to Emily Welty et.al (2013).[151] There are multiple layers that are constantly changing, evolving, 'ever in dialectic'. But just because the demonstration was taking place at Wall Street doesn't mean that it was limited to that space. In NY, 'demonstrations, marches, and direct action enabled OWS to project its power beyond the spaces of its occupations and assemblies of their social critique,'[152] but these demonstrations were not only limited to US. Occupy Movement 'spread to 951 cities' including one protest even in Antarctica.[153] Occupy movements, which started against economic inequality, became a symbol of international cohesion of the oppressed civil society against the oppressors. Though, the Occupy Movement and Arab Spring haven't generated immediate utopian goals that were once articulated by protesters. Nonetheless, these protests demonstrate that global civil society has become very active in the Third Epoch of Development.

Implications of Iraq War and Arab Spring have led to continuous turmoil in the Middle East. Estimates vary about Syrian War; on-going now for five years, but one estimate is 400,000 deaths.[154] ISIS, according to UN, has killed at least 18, 802 civilians and more than thirty six thousand have been injured. During the same period, about three million people have been 'internally displaced' in ISIS controlled region.[155]

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[144] The Arab Spring pg 10
[145] Arab Spring pg 211-212
[146] Adam Roberts et.al Edited, Civil Resistance in the Arab Spring: Triumphs and Disasters, 2016, Pg 271
[147] Civil Resistance in the Arab Spring pg 282
[148] Civil Resistance in the Arab Spring pg 326
[149] Occupying Political Science, 2012, pg 1
[150] Occupying Political Science, 2012, pg 248
[151] Occupying Political Science, 2012 pg 26:
[152] Occupying Political Science, 2012 pg 29
[153] https://www.washingtonpost.com/blogs/blogpost/post/occupy-the-tundra-antarctica-protests-spread-to-951-cities-thanks-in-part-to-viral-photos-online/2011/10/17/gIQAIU9LuL_blog.html
[154] http://www.aljazeera.com/news/2016/04/staffan-de-mistura-400000-killed-syria-civil-war-160423055735629.html
[155] http://www.nbcnews.com/storyline/isis-terror/isis-death-toll-18-800-killed-iraq-2-years-u-n499426

This instability has led to mass migration into European countries creating a hostile environment for the refugees as well as citizens. This has led to polarization among citizens based on fear and hysteria against mass immigration. Occupy Movement and Arab Spring showed consolidation between the internationally oppressed civil societies, but, at the same time, fear of mass migration flash complex relationship that exists between international civil societies. There is no hegemony in the historical bloc. Each agent, state, market and civil society, has taken or failed to take action to establish dominance. It is in this political context that Sustainable Development Goals are approved by United Nations.

7. CONCLUSION

In the First Epoch of Development, developmental priority was Growth, economic growth and modernization. Amartya Sen, among many writers, led the counterpoint during the Second Epoch by questioning the validity of economic growth as the centre of developmental discourse. Third Developmental Discourse has become a complex process where each and every policy is present. Instead of becoming a ‘melting pot’ where policies merge, development discourse has become a ‘Developmental Thali’. Each and every policy of the past, from economic growth to sustainable development, is present side by side.

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The Balancing Act of Economic Growth and Environment Preservation: A case study of Guam

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Abstract:

For many small islands like the Micronesian islands, tourism is a major revenue generating activity. There are approximately 1.3 million tourists that visit Guam alone and a goal of 2 million projected by the year 2020, based on a development plan to shape Guam's economic future. For smaller islands, especially those that have limited financial resources, preparing for such growth may be delayed and consequently have unintended consequences for the local culture and environment. This paper is a literature review to discuss a framework to promote maintaining the balance between economic growth and environmental preservation in Guam which includes establishment of more stringent environmental policies, as well as stronger initiatives for recycling and conversation. An additional purpose is to identify whether Guam and other outlying islands within the Micronesian chain have the monetary and local infrastructure to handle conventional mass tourism of sea, sun and sand. A final purpose of this review is to offer practical examples for these host communities to lessen the environmental pressure from this rapid tourism growth and still achieve their economic goals.

The socio-economic contribution of marula harvesting to rural household livelihoods in Swaziland

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ABSTRACT

Swaziland is a Low-Middle-income economy country with a per-capita Gross Domestic Product (GDP) of US$ 5,940 per annum with a high poverty level of 69%. This has led a majority of the poor people in the rural areas to exploit natural resources such as harvesting wild fruits including marula to earn a living. A cross-sectional survey that was embedded in an exploratory and descriptive approach was carried out at the Mpolonjeni constituency in the Lubombo region of Swaziland to determine the socio-economic contribution of marula to rural household livelihoods. Both quantitative and qualitative research approaches to data collection and analysis were employed. A questionnaire survey was conducted on a sample of 411 households as well as in-depth interviews on 20 key informants from five different organizations directly connected to natural resources use in Swaziland. The study established that marula contributes in many ways to livelihood of rural households. It found that 53.3% respondents in the questionnaire survey supplemented household incomes by harvesting marula. Another 90.7% considered marula a very important source of household income and 77% of individual respondents earned an equivalent of US Dollar 83 per season of which 86.2% of the respondents indicated that they use it for several purposes including paying school fees, buying food, electricity, and medication. Other socio-economic contribution of marula included its use as a source of food; production of body care products; brewing; creating social ties; and cultural and spiritual beliefs and practices. At least 53.5% of the respondents reported that their households would not survive without the income generated from marula harvesting thus depletion of marula would render their households vulnerable. The study concluded that marula contribute significantly to rural livelihoods. It recommended that marula should be harvested sustainably and conserved through planting in the fields in agro-forestry practices so as to meet the needs of the current and future community members.

Key words: Marula harvesting, socio-economic, cultural, Swaziland, vulnerable

INTRODUCTION

Ecosystems offer a number of services that people tape for survival and livelihood. People interact with these services, and are fundamentally linked to social structures and processes. As such, people form an integral part of ecosystems as they derive a range of services from them and also act as drivers influencing ecosystem processes (Levin, *et al*., 2009). Swaziland has a population of 1,230,985 (WHO, 2014). It falls under the low-middle-income economy (L-MIE) countries, with a per-capita Gross Domestic Product (GDP) of US$ 5,940 per annum as of 2014 estimates (Population Reference Bureau, 2015). Hence, the poverty rate is estimated at 69% (Nindi & Odhiambo, 2015; World Bank Group, 2011). Therefore, a majority of the rural poor especially resort to exploiting natural resources, including the harvesting of wild fruits, to generate an income and earn a living.

Poverty alleviation featured as Goal One among both the past eight UN Millennium Development Goals (MDGs) and the current 17 UN Sustainable Development Goals (SDG) (Lunn, *et al*., 2015; United Nations, 2012) which calls for ending of poverty in all forms. People depend on natural products for food, shelter, medicine, and source of energy, income, oxygen, recreation, and spiritual sustenance (Sunderland, *et al*., 2004). This means that local people's livelihoods and even their survival depend on the exploitation of local and regional natural resources (Fisher, 2005). One such natural resource base being exploited for poverty alleviation is non-timber forest products (NTFPs) which includes, amongst others, the harvesting, processing and selling of marula products.

The marula tree (*Sclerocarya birrea*) is a member of the *Anacardiaceaea* family which is made up of about 70 genera and 650 species that include among others, the mango tree (*Mangifera indica*), pistachio (*Pista ciavera*), cashew nut (*Anacardium occidentale*) and the pepper tree (*Schinus molle.* L.) (Mojeremane & Tshwenyane, 2004). *Sclerocarya birrea caffra* (marula) is one of three species of *Sclerocarya*, the others being *Sclerocarya gillettii* and *Sclerocarya multifoliolata* (Hall, 2002). It grows abundantly in Swaziland, especially in the lowveld and the lower parts of the middleveld. About two million marula trees grow in Swaziland and each tree can produce up to 500kg of fruits per year (UNDP, 2012). Marula is a large dioecious tree that grows to about 15m in height with spreading crowns and dense foliage (Mojeremane & Tshwenyane, 2004). It produces fruits that are rich in minerals and vitamins and whose fresh ripened mesocarp is edible. According to (Hall, 2002), the stone of a marula fruit contains nut-like seeds that are rich in protein and oil and can be eaten fresh, mixed and cooked with other foods or stored for later consumption. This makes marula an integral part of the diet, tradition and culture of rural communities in southern Africa and thus sought after for many commercial initiatives (Shackleton, *et al.*, 2002).

Swazis have been collecting marula fruits and seeds for livelihoods in the form of food and for producing a traditional brew known as *Buganu* from time immemorial. The latter is largely consumed during traditional festivals or sold to local customers for income generation (Magagula, 2012; Mathunjwa, 2010; Nkambule, 2015). They have used the kernels in relishes, eaten the fresh fruits and seeds, and used the bark for relieving stomach aches and for spirituality (Marula Natural Products, 2012; Swazi Secrets, 2009). Marula also features extensively in traditional ceremonies, such as the Buganu Ceremony (BC), celebrated annually in the country where people gather together with the King (The *Ingwenyama*) and Queen Mother (The *Indlovukazi*) to celebrate the marula (Magagula, 2012; Mathunjwa, 2010; Nkambule, 2015). This annual ceremony marks the beginning of the *Buganu* season whereby after the ceremony everyone becomes free to drink the brew (Jele, 2013).

In the past few decades, marula has increasingly gained popularity in the international market due to demand for its many by-products, such as marula oil and the well-known Amarula cream liqueur (Cant & Machado, 2010; Shackleton, *et al.*, 2002). This turn of events in the demand for marula products in the international markets brought hope to many developing countries in the sub-Saharan Africa in the fight against poverty. Swaziland, like many of the developing countries, continues to fight the battle for economic growth and poverty alleviation. This is compounded by the current global economic meltdown, reduction in SACU revenue, and the environmental challenge of global climate change which is impacting developing countries the most (Basdevant, *et al.*, 2011).

Recognizing the social, cultural and economic values of marula, the Queen Mother established two commercial processing plants known as Swazi Secrets and Swaziland Marula as initiatives to empower rural women economically through enterprising on marula harvesting and processing. These initiatives have attracted a large number of Swazis especially women to scout the forests and fields around their homesteads in search for marula fruits and seeds to sell and earn an income. However, the socio-economic contribution of marula to the rural households is not known. Hence, this paper seeks to elucidate the socio-economic contribution of marula to rural households and close up the literature void.

Given the current rate of marula fruit and seed harvesting in Swaziland, marula could be driven to extinction as the very seeds that could contribute to new trees are being removed from the natural habitat. It is clear, therefore, that the potential depletion or extinction of marula in Swaziland could compromise the livelihood activities of large numbers of the rural poor in terms of income generation and well-being as they derive their livelihoods from harvesting marula. Should marula get depleted, the effects would impact on the poor rural women harvesting the raw material and would also trickle down to the marula processing enterprises.

METHODOLOGY

The study was carried out in the Kingdom of Swaziland – a small landlocked country in southern Africa with an area of 17,363 km^2 (Encyclopedia of nations, 2011). Swaziland is bordered by the Republic of Mozambique to the east and the Republic of South Africa to the north, west and south. Administratively, Swaziland is divided into four regions – the Hhohho, Manzini, Shiselweni and Lubombo (the latter is the region where the study was conducted). Swaziland is also divided from the west to the east into four physiographic zones distinguished by their elevation and relief into the *Highveld*, Middleveld, *Lowveld*, and *Lubombo escarpment* (Boycott, *et al.*, 2007; UN, 2002).

The study was carried out in Mpolonjeni Constituency (*Inkhundla*) in the Lubombo, located midway between Siphofaneni, Big Bend, and Siteki. The study covered all four chiefdoms of the Mpolonjeni Constituency: KaNdzangu, KaNcgina, KaShoba, and Mpolonjeni Inkhundla. This site was chosen due to its proximity to the two marula processing enterprises that buy and process marula fruits and seeds in Swaziland. Given that the landscape, geology, soils, climate and biodiversity of Swaziland vary significantly across the country (African Economic Outlook, 2012; Urquhart & Lotz-Sisitka, 2014), many marula trees grow in this area, and hence it was prudent to site the research project in this area. In addition, due to its remoteness, high poverty levels and frequent droughts, a majority of people in the study area supplement their income by harvesting and selling wild fruits, and mainly marula.

The study was embedded in an exploratory and descriptive research approach and designed around a cross-sectional socio-economic survey as well as a vegetation survey. (This paper only reports on the outcome of the socio-economic survey). Both quantitative and qualitative approaches to data collection and data analysis were employed. Three populations were targeted for this study: i) the marula trees of the Lubombo Region; ii) the human communities of the Lubombo Region and iii) key informants from the following key stakeholder organizations: Swazi Secrets, Swaziland Marula, the Swaziland National Trust Commission (SNTC), Swaziland Environment Authority (SEA), and leaders of the women association that sells marula fruits and kernels to both Swaziland Marula and Swazi Secrets.

Respondents were purposively selected from the four chiefdoms within the Mpolonjeni Constituency. Sampling the community for the socio-economic survey occurred in two phases: Firstly, a probability sampling method was used where 411 community members were randomly drawn from the target areas. Using a Microsoft Raosoft sample size calculator (Microsoft, 2010) and accepting a 5% confidence interval (error level) and a 96% confidence level, the sample size was calculated from the target population of 14,716 people living in the Mpolonjeni Constituency (Table 1).

A multi-stage random sampling procedure was then used to select the households to be included in the study (through assigning numbers to the households and then selecting every 3rd household for inclusion into the study sample), and then randomly select an adult individual participant from the selected household. However, for households where there was no adult respondent, the eldest child (of age not below 17 years) within that homestead was selected to participate in the study. A purposive sampling method was then used to select 20 key informants from stakeholder companies and organizations to participate in the in-depth interviews (Table 1). This generated a total sample size of 431 participants.

To gather the data, two main research instruments were used, namely a structured questionnaire for the 411 household members and an in-depth interview schedule for the 20 key informants. A diary was also kept to record any other information that was not captured by the questionnaire and in-depth-interview schedule. The questionnaire was developed in a way that it focused particularly on quantifying the socio-economic contribution of marula to household income and livelihoods. It also focused on the impact of marula harvesting on the availability and sustainability of marula. Furthermore, the questionnaire focused on the effect of marula depletion on the livelihoods of the people in the event that marula trees become depleted or over-consumed.

Table 1: Sample breakdown and data collection methods

Area/organization/key informants	**Sample size**	**Respondents**	**Data collection method**
Mpolonjeni Constituency	411	Community household members	Structured survey questionnaire
SNTC key informants	4	Environmental Education Officers	In-depth interviews
Swaziland Environment Authority key informants	4	Environment Officers and the Communications Officer	In-depth interviews
Swazi Secrets key informants	4	Managing Director and the Public Relations Officer	In-depth interviews

Swaziland Marula key informants	4	Managing Director and the Public Relations Officer	In-depth interviews
Women association that sells marula kernels key informants	4	Members of the association	In-depth interviews
Total	**431**		

Source: Author (2013)

To ensure validity and reliability, the research instruments had to be developed from an extensive literature review and vetted for validity and reliability by experts in the field of socio-economic studies, biodiversity conservation and forest management drawn from the University of Free State, University of Swaziland and the Forestry Department of the Ministry of Tourism and Environment, Swaziland. In addition, the researcher selected and trained research assistants from the Department of Environmental Health Sciences at the University of Swaziland. The research assistants were trained on how to use the questionnaire and ask questions in order to ensure the highest quality of the data. The questionnaire was also translated into siSwati by two language experts, given that the respondents were not adequately conversant with the English language.

The questionnaire was pilot-tested at Ngculwini Inkhundla, which was not included in the study area, to identify the potential problems of the research instruments and research procedures. This gave room for necessary modifications of the instruments and logistics of data collection before the actual fieldwork started. The research assistants were closely supervised by the researcher who was part of the data collection team. All the data were checked daily by the research assistants (against each other) and counterchecked by the researcher for any discrepancies and to ensure completeness and accuracy. All shortfalls were rectified.

Informed consent was sought from all the relevant authorities and stakeholders. This was done by the researcher through holding meetings with the relevant concerned parties. The identities of the people participating in both the household survey and key informant interviews were not revealed save for the organizations of the latter in order to uphold their confidentiality, integrity, values and dignity. In addition, before the start of the interviews, participants were informed about their rights to, decline to answer any particular question(s); withdraw from the study at any time; ask any questions about the study at any time during participation; provide information on the understanding that their names would not be used unless permission is given to the researcher; and have access to full or summary of the findings on request. Consent forms were provided and those who could read and write signed them, while those who were not able to read and write were requested to give a verbal consent. The researcher also sought permission to take pictures and notes where necessary. The interviews were conducted in a respectful, polite, responsive, frank, sensitive and well-behaved manner. The interviewees were also provided with the researcher's addresses in case they needed to have any correspondence with him.

The data were checked for completeness and quality and were edited to ensure that they were accurate, consistent with facts, uniformly entered, well completed and arranged to facilitate coding and tabulation. Data cleaning was then done to check for treatment of missing values which, in the analysis, were left out to avoid unnecessary skewing of the findings. The data were then presented in the form of figures and tables. The qualitative data were content-

analysed and subjected to classification according to emerging thematic areas. Analysis of quantitative data was done by using the Statistical Package for the Social Sciences (SPSS version 20) (Microsoft, 2010). Descriptive statistics (frequencies and percentages) were used to describe the categorical data.

RESULTS

Table 2 shows the demographic data of the study population. The table shows that, out of the 411 households that participated in the socio-economic survey, 77% (n=316) of respondents were females and only 23% (n=95) were males – thus suggesting a very skew gender distribution in the marula enterprise in favour of females. Probably, labour migrancy is one of the factors that contributed to a large number of female-headed households in the study area. Being a remote area, most of the men and young adults were reported to have gone to the urban areas and neighbouring countries in search for jobs. Labour migration is not new in Swaziland. Several authors such as Booth (1986); Kowet (1978); & Leliveld (1997) claim that since the turn of the 19th Century, labour migration from Swaziland to South Africa became a major feature of the economy of Swaziland. Another possible reason for the high proportion of females in the sample may relate to the custom of polygamy - a practice that is common in Swaziland (OECD Development Centre, 2015). Some of the female respondents in the study, lamented during the interviews that, "their men were gone away with another wife". In addition, traditionally in Swaziland it is mostly the women who partake in marula collection and selling (Dlamini B. M., 31st December 2013, University of Swaziland, per. Com.).

Table 2 also shows that the largest proportion (42.1%; n=173) of the participants were of the age group 20 to 39 as compared to those between the age groups 40 to 59 (37.2%; n=153), 19 and younger (5.1%; n=21), and 60 and older (15.6%; n=64). Out of the 5.1% (n=21) respondents of the age group 19 years and younger, 81% (n=17) were school goers and the other 19% (n=4) were not school goers but were engaged in small-scale businesses such as hair dressing, selling snacks at the market places, and doing household chores. The age group of 60 years and older was comprised of elderly people who are either pensioned, or receiving elderly grants from government, or receiving help from their children and relatives who are still active and probably working, and/or engaging in marula harvesting to augment the meagre income they receive. Some of the elderly participants complained of being sickly and could not manage to walk to distant places to collect marula fruits. In general, a majority of the people in the age groups 20 to 39 and 40 to 59 are still active and probably have much more responsibilities of looking after their nuclear and extended family members as compared to the former two groups, hence leading them to engage more in marula harvesting to meet the several demands for their households.

Table 2: Demographic data

Gender (N=411)	**N**	**%**
Male	95	23
Female	316	77
Age (N=411)	**N**	**%**
19 years and younger	21	5.1
20 to 39 years	173	42.1
40 to 59 Years	153	37.2
60 Years and older	63	15.6

Marital status (N=411)	**N**	**%**
Never Married		33.9
Married or living together		47.3
Separated or divorced		5.4
Widowed		13.4
Level of Education (N=410)	**N**	**%**
Never attended school	87	21.2
Did not complete primary school	79	19.3
Completed primary school	39	9.5
Did not complete secondary school	86	21
Completed secondary school	64	15.5
Did not complete tertiary education	26	6.3
Completed tertiary education and above (degree or diploma or higher certificate, etc.)	29	7.1
Employment status (N=331)		
Formally employed	84	25.4
Not formally employed	247	74.6

Furthermore, Table 2 shows the marital status of the respondents. Among the 410 respondents who responded to the question on marital status, the largest proportion (47.3%; n=194) were married or living together. The rest were either never married (33.9% n=139), separated or divorced (5.4%; n=22), or widowed (13.4%; n=55). The group that was never married comprised of school going children and children who were not yet married but leaving in the households. Households that have at least two adults generally have greater opportunities to avoid poverty compared to households with one adult as the second one on average will add more to potential income than to needs (Cancian & Reed, 2009). Those married or living together may actually accrue some benefits through the marriage or relationship, although the implications of living together for exclusively poverty measures as well as for actual economic gains and well-being are complex and may in a way compromise the economic status of the bread winner in that relationship.

In addition, Table 2 shows the distribution of the education level amongst the study population. It shows that 21.2% (n=87) of the respondents never attended school. Another 19.3% (n=79) of the respondents did not complete primary school and 9.5% (n=39) completed primary school. Furthermore, the table shows that 21% (n=86) of the respondents did not complete secondary school and another 15.5% (n=64) completed secondary school. Yet another 6.3% (n=26) did not complete tertiary education, and only 7.1% (n=29) completed tertiary education and above. The majority of respondents therefore have very low levels of education thus rendering them economically vulnerable. Education has been found by various studies to be a significant negative determinant in extraction of indigenous fruits and other non-timber forest products for either food or income generation in that those with a high level of education tend not to engage in such an enterprise but mainly those with a low level of education does (Adhikari *et al*., 2004; Lingani *et al*., 2009).

Finally, Table 2 shows that, the study population was composed mainly of individuals who are not employed (74.6%; n=247) with a minority (25.4%; n=84) being employed. Individuals who are employed are busy and already have a source of income, which means that they are less likely to engage in harvesting marula fruits for sale. In a study conducted by Belaya & Hanf (2011) in Russia it was found that 56% of the sample were employed and did

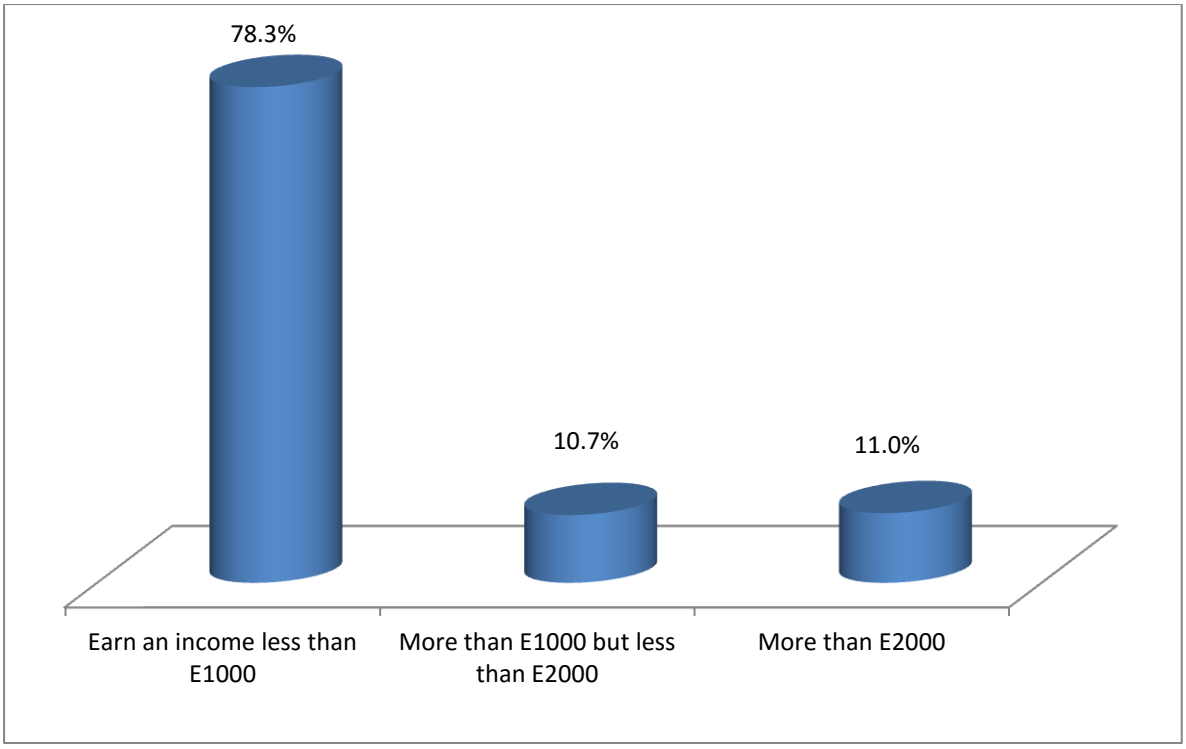
not partake in harvesting indigenous fruits for sale which seems to agree fairly well with the findings of this study.

The respondents were asked to indicate other sources of income for their households as presented in Table 3. Majority (73.2%; n=255) depended on subsistence crop production, others (36.6%; n=127) relied to a very low level on rearing animals/breeding cattle, goats and chickens yet others sourced an income from selling marula (50.4%; n=173). Others depended on harvesting and selling other wild fruits and seeds except marula (54%; n=54) and other (12.4%; n=37) relied on other sources such as collecting Mopani worms, wild fruits such as wild berries and guava and wild vegetables such as *Am*aranthus (*umbidvo*), Black Jack (*Imbuya*) and okra (*ligusha),* and being housewives who depended on their husband's income. The finding indicates that the respondents mainly relied on subsistence crop production, animal rearing, and natural capital for sustaining their livelihoods. In some situations as observed by Campbell *et al*. (2002) as well as Shackleton & Shackleton, (2004), in the dry woodlands of southern Africa, the trade in natural products may be one of the few accessible local income generating options available to the rural poor, and to women in particular.

Table 3: Sources of livelihood in the study area

Source of income	**Yes**		**No**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**
Subsistence crop production	255	73.2	94	23.8	349	100
Rearing animals/breeding cattle, goats and chickens	127	36.6	219	63.4	346	100
Harvesting and selling marula	173	50.4	171	49.6	344	100
Harvesting and selling other wild fruits and seeds (except marula)	54	16	285	84	339	100
Other (such as collecting Mopani worms, wild vegetables etc.)	37	12.4	261	87.6	298	100

Figure 1 shows that the majority of the respondents (78.3%; n=309) earned a monthly income of less than E1000 (USD69). Another 10.7% (n=42) of the respondents earned between E1000 and E2000 and another 11% (n=43) of the respondents earned a monthly income of more than E2000. This finding again reflects the poverty stricken nature of the study area as the majority of the people earned a meagre monthly income and thus grabs the marula season as an opportunity for earning an extra income to meet their household needs.

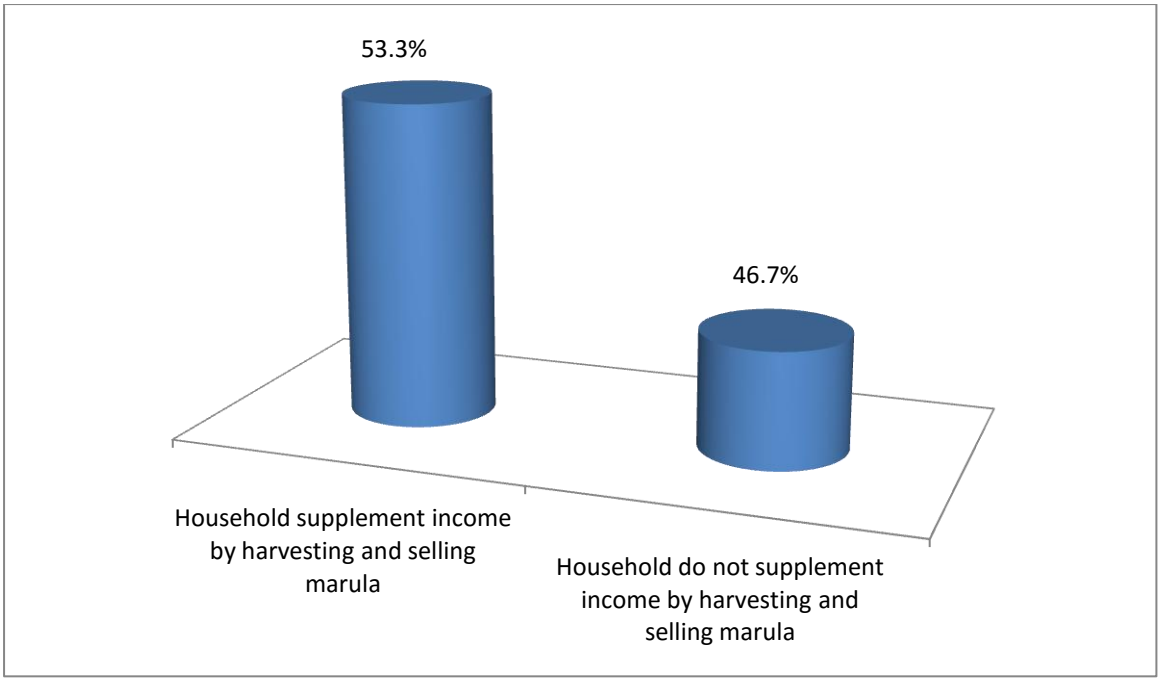


N=394

Figure 1: Personal monthly income of the respondents

Respondents were asked to indicate whether they supplemented their household income by harvesting marula. Although all the households interviewed collected marula for different uses such as food, medicinal, fodder, and carving, not all of the respondents collected marula for the purposes of supplementing their household income.

Different options regarding the household use of marula were presented and the respondents were asked to tick all the applicable uses they use marula for. Table 4 shows that the majority (76.4%; n=216) of the respondents use marula for brewing buganu. This was followed by those who use marula as a source of food (67.5%; n=191) and those who sell the kernels (51.9%; n=147) to earn an extra income which agrees quite well with Marula Natural Products (2012); Mabaya *et al.* (2014) who highlights the different uses of marula.



N=411

Figure 2: Households that supplement their income by harvesting marula

Table 4: Uses of marula amongst the respondents in the study area

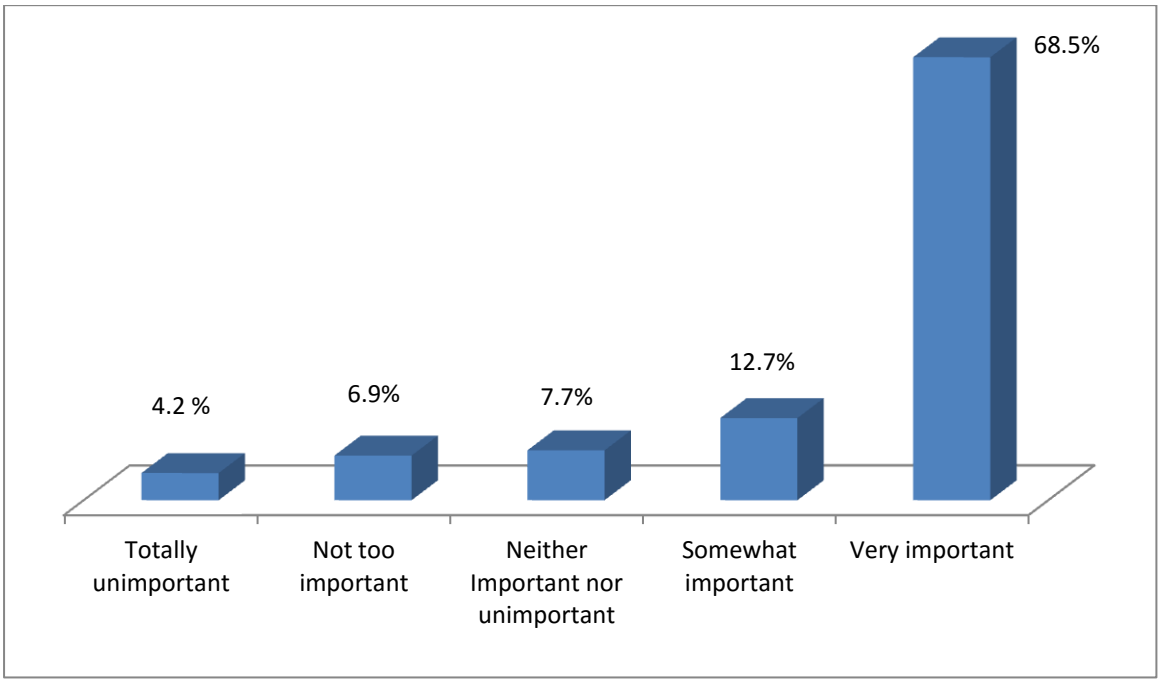
Use of marula	Yes		No		Total	
	N	%	N	%	N	%
Carving	24	8.6	256	91.4	280	100
Brewing buganu	216	76.4	66	23.6	282	100
Selling kernels	147	51.9	136	48.1	283	100
Medicinal purposes	35	12.5	245	87.5	280	100
Animal fodder	28	10	251	90	279	100
Fencing	6	2.1	274	97.9	280	100
Cultural practices	70	24.8	212	75.2	282	100
Spiritual practices	34	12.2	244	87.8	278	100
For food	191	67.5	92	32.5	283	100
Kernel oil for cooking and body care	65	23.5	212	76.5	277	100
Other (the stones and green seeds are used for playing games such S*intjuba, inketo*)	3	1.5	203	98.5	206	100

The respondents also indicated that they use marula for medicinal purposes (12.5%; n=35) which also agree well with similar findings of previous studies (Elijah, *et al*., 2012; Hal, 2013; Hall, 2002; Ojewole, *et al*., 2010). Furthermore, Table 3 shows that marula is also used for carving artefacts (8.6%; n=24), as animal fodder (10%; n=28), for fencing (2.1%; n=6), for cultural practices (24.8%; n=70) (especially the *Buganu* Ceremony), and spiritual purposes (12.2; n=34) [including its use in chasing away ghosts (*tokolosis)*, for divination, and for "washing away" evil spirits].

The respondents who supplement their household income through harvesting and selling marula were asked to indicate if marula was an important source of their household income. Out of the 219 respondents who supplement their household incomes by harvesting marula, Figure 3 shows that the majority of the respondents (68.5%; n=177) considered marula as a very important source of household income. Another 12.7% (n=33) viewed marula as somewhat important in augmenting their household incomes. However, 7.7% (n=20) of the respondents considered marula as neither important nor unimportant, 6.9% (n=18) viewed marula as not too important and 4.2% (n=11) felt it is totally unimportant.

On further interrogation, those who did not consider marula as very important or somewhat important indicated that marula produce fruits only seasonally and therefore they had to find other sources of incomes since relying only on marula would push them to the edge in as far as household income is concerned during off season. A majority of the respondents viewed marula as a very important source of household income, thereby confirming the crucial role marula plays as a source of household income for the households in the study community. On-site observations showed that the households of those respondents who viewed marula as a very important source of income were poverty stricken and any depletion/scarcity of marula would adversely impact on their livelihoods. Shackleton *et al*. (2000) observed similar findings where they reported the importance of marula fruits and their products featuring prominently in household income generation. The finding in this study contextualizes the importance of marula amongst the poor households in the Mpolonjeni constituency.

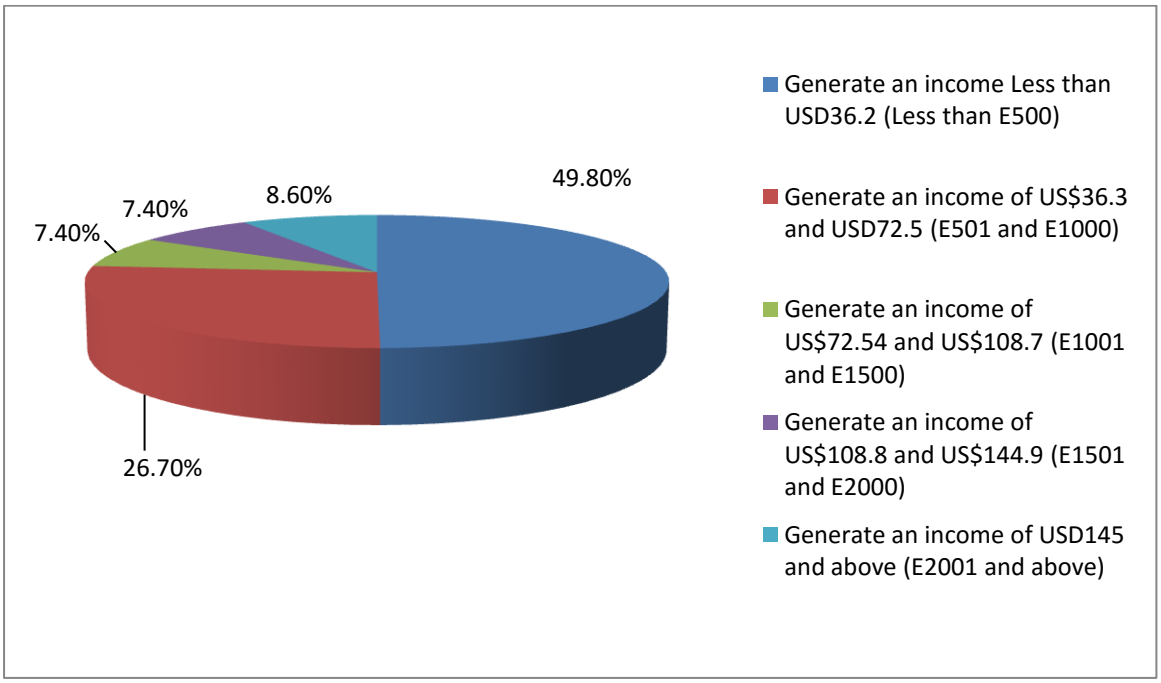
In general, even though the marula tree and its products will not be able to solve the challenges of poverty in the study area, it does have a key role to play in meeting a number of livelihood needs ranging from food to medicine, electricity, school fees for children and cash for the household. Various studies globally have left no doubt that biodiversity and natural products contribute to the well-being and, sometimes, the very survival of millions of poor rural households (Arnold, 2002; Belcher, Ruiz-Pe´rez, & Achdiawan, 2005; Fisher, 2004; Scherr *et al*., 2004).



N=219

Figure 3: Importance of marula as a source of household income

Figure 4 shows the total income earned by the households that supplement their income through harvesting and selling marula. It shows that a good number of respondents (49.8%; n=109) generated an income less than US$36.2 (less than E500) per season from marula harvesting. In addition, 26.7% (n=59) of the respondents generated an income of between US$36.3 and US$72.5 (E501 and E1000). Other respondents 7.4% (n=16) indicated that they generated an income of between US$72.54 and US$108.7 (E1001 and E1500) and others 7.4% (n=16) generated an income of between US$108.8 and US$144.9 (E1501 to E2000). Finally, another group of respondents (8.6%; n=19) indicated that they generated an income of US$ 145 and above (E2001 and above). These findings are in agreement with Shackleton *et al.* (2000) who found that households accrued earnings from marula ranging from US$ 87 to 149 per season from marula.



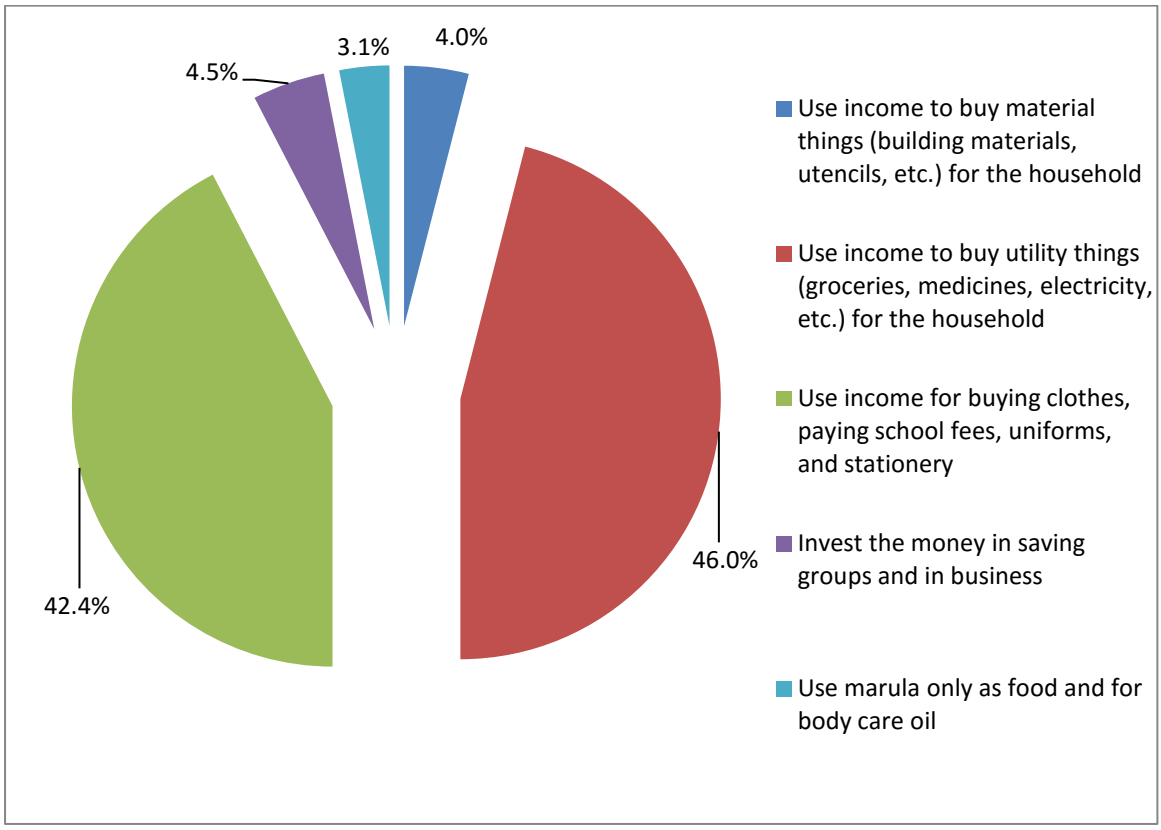
N=219

Figure 4: Total income generated by households from harvesting and selling marula per season

Further agreeing with this finding Shackleton (2004) in the Bushbuckridge, South Africa reported that women trading in marula products earned on average an income of R500 (US$36.23) per season. The importance of marula to household income generation has also been highlighted by the World Intellectual Property Organization (WIPO) (2015) where they emphasize important role the marula tree play in the lives of tens of thousands of rural producers, their families, and communities. This study still agrees well with WIPO (2015) who indicated that women were extracting marula in Namibia for personal use or to sell it locally and that by 2010, 2000 women were accruing over US$60,000 annually from marula. Figure 5 shows that the respondents do generate an income from marula harvesting thus emphasizing the important role marula plays in contributing to household income. Much as

the income might look like a small amount, the value attached to it is great as demonstrated by the different uses of the income the households earn from harvesting marula (Figure 5).

Figure 5 shows the uses of the income earned from selling marula by the households in the study area. Out of the 224 respondents who answered this question, a good number (46%; n=103) of the respondents indicated that they use the income for buying consumable things such as groceries, medicines, and electricity for the household.



N=224

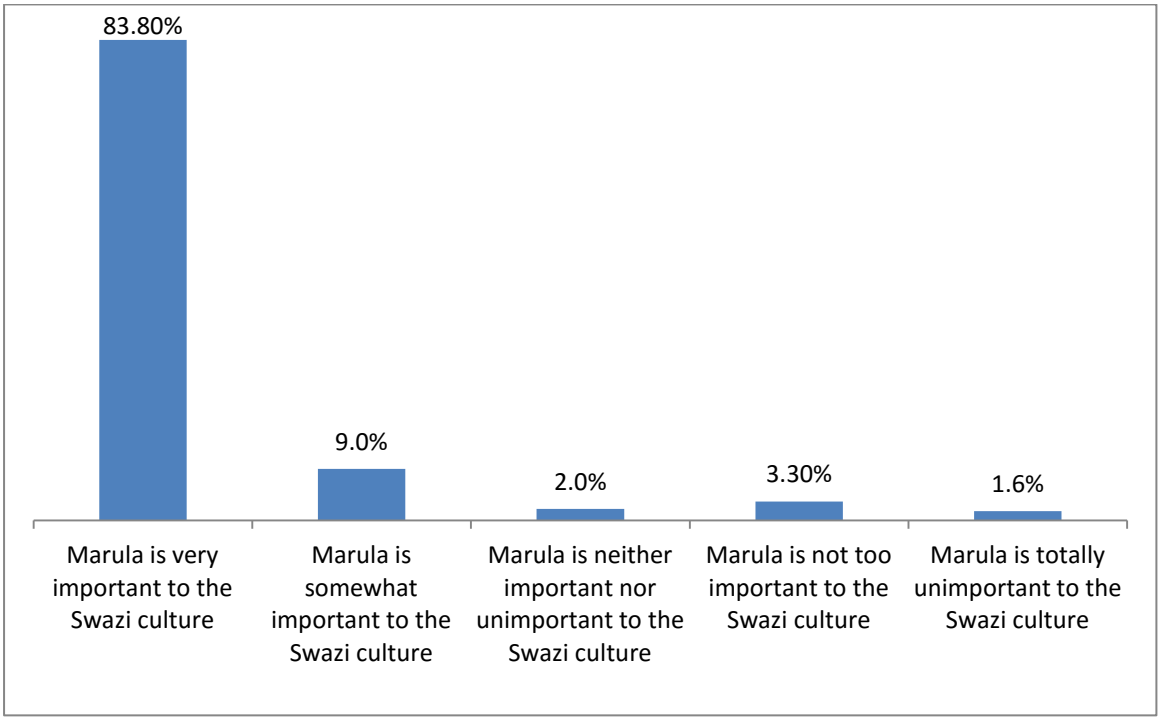
Figure 5: Use of income earned by household from harvesting and selling marula

Another 42.4% (n=95) of the respondents indicated that they use the income for buying stationery, clothes and uniforms for their children, and paying school fees. A small percentage (4.5%; n=10) indicated that they invested the money earned in some local saving groups and in small-scale businesses. Others (4%; n=9) said they use the income for buying material things including building materials and utensils for the household's use. Lastly another 3.1% (n=7) of the respondents indicated that they do not harvest marula for sale but only for consumption as food and locally making body care products (privately pressing out the oil at home) for private use. Figure 5 shows that most of the income earned from marula harvesting is used for buying utility products such as groceries, medicines, electricity; and buying clothes, paying for school fees, school uniforms, and stationery.

These incomes are relatively low and highly seasonal but a crucial contribution of cash at a time of the year when households often experienced shortages of cash after the Christmas season especially – a time when schools open and school fees, uniforms and stationary are needed for school going children. This is a similar finding to that of Mabaya *et al*. (2014) and

Shackleton & Shackleton (2002) who reported that hundreds of local rural people in Botswana and South Africa, primarily women, harvested marula fruits and used the income to pay for healthcare, school uniforms and fees and improving their buildings. Similar findings were also observed by Wynberg *et al*. (2002) in South Africa and Namibia where they reported that although not a large amount, the timing of the marula season at the beginning of the school year makes the extra income extremely important for the payment of school fees, clothing, and the purchase of food and household goods, particularly in areas with high levels of poverty.

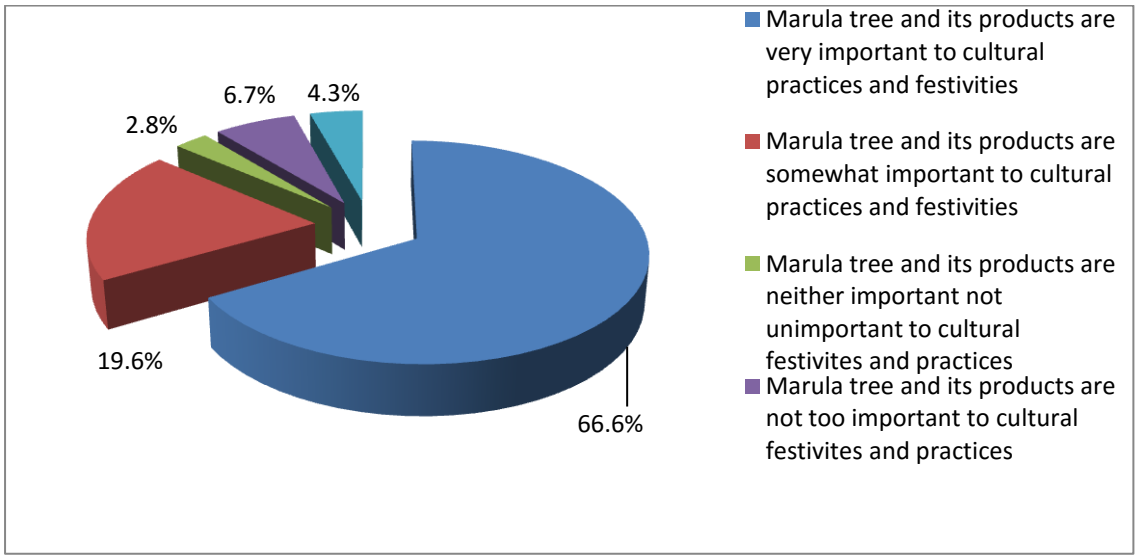
Respondents were asked to indicate whether marula is important in Swazi cultural practices or not. Out of the 365 respondents who answered the question, Figure 6 shows that the bulk majority 83.8% (n=306) of the respondents said marula is very important in the Swazi culture. Another 9% (n=33) considered marula as somewhat important in the Swazi culture, 2.0% (n=8) said marula is neither important nor unimportant in the Swazi culture, 3.3% (n=12) said marula is not too important in the Swazi culture, and 1.6% (n=6) said marula is totally unimportant to the Swazi culture. On further discussions, those who said marula is very important indicated that it is particularly very important in the Buganu Ceremony. This seems to agree very well with several authors who reported the importance of marula in African cultures and festivities (Helm, *et al*., 2011a; Nwongwu, 2006; Shackleton, *et al*., 2002). The respondents indicated that during the Buganu ceremony, people of all walks of life come together from different parts of Swaziland to present their gifts to their Majesties and at the same time strengthening social ties in the country. It was observed during one of the ceremony attended by the researcher that people bring different kinds of merchandise to sell during the occasion thus contributing to the improvement of household income.



N=365

Figure 6: Importance of marula in the Swazi culture

Respondents were asked to indicate the importance of the marula tree and its products to cultural festivities and culture. Out of the 326 respondents who answered the question, Figure 7 shows the responses on the importance of the marula tree and its products to cultural festivities and practices. It was found that 66.6% (n=217) of the respondents considered the marula tree and its products as very important to cultural festivities and practices. Another 19.6% (n=64) said marula is somewhat important to cultural festivities and practices. Yet another 2.8% (n=9) considered marula as neither important nor unimportant to cultural festivities and practices. Another 6.7% (n=22) believed that marula is not too important to cultural festivities and practices and finally 4.3% (n=14) said marula is totally unimportant for cultural festivities and practices.



N=326

Figure 7: Importance of marula and its products for cultural festivities and practices

Figure 7 indicates the responses of the respondents about the various cultural practices that are associated with the marula tree in the study area. The majority (98.5%; n=372) of the respondents indicated that the *Buganu* ceremony was the most important cultural ceremony associated with the marula. Several authors have reported on the importance of marula to cultural festivals and practices in Africa (Marula Natural Products, 2012; Nwongwu, 2006).

Other respondents to the study (0.5%; n=2) indicated that marula trees provide products that are used traditionally (such as sangoma dice, for chasing away evil spirits, and game counters) which agrees fairly well with other researchers who reported that culturally the nuts of marula are worn as necklaces to ward off evil spirits and illness (Nwongwu, 2006; Wynberg, *et al*., 2002). Another 0.5% (n=2) of the respondents said marula is given to ancestors at the kraal to get blessings from the ancestors, and the other 0.5% (n=2) said marula is used as food and/or pressed locally for getting cooking oil and for body care lotion – especially for getting rid of stretch marks due to aging or after a woman has given birth. This has been highlighted by several authors who point out that marula seeds contain non-drying oil which is rich in protein and is used in combating stretch marks due to its anti-aging properties (Abdalbasit & Ibrahim, 2012; Ojewole *et al*., 2010; Wynberg, *et al*., 2002).

These findings are in concert with those of several authors who claim that marula is used in a wide range of cultural practices such as marula stones being used as divination pieces, game counters or as kindling (Ngorima, 2006; Nwongwu, 2006). The significant cultural value of marula therefore means that it plays an important role in a range of socio-cultural practices and is important in building social capital amongst the rural Swazis (Bennett, 2010; Bhuiyan *et al*., 2012).

CONCLUSION AND RECOMMENDATION

The study revealed that marula plays a crucial role in socio-economy and livelihoods of rural households. It contributes significantly to income generation, food and nutrition, and plays a formidable role in cultural practices and festivities. The paper also showed that in the event of marula depletion/extinction, many rural households would be adversely affected as their only fall back option of livelihood would have been removed. The paper therefore recommends that sustainable ways of marula exploitation be sought in order to perpetuate the resource.

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THE STATISTICAL RELATIONSHIP BETWEEN INORGANIC FERTILIZERS CONSUMPTION AND AGRICULTURAL PRODUCTION VALUE: INFERENCES FOR AGRICULTURAL SUSTAINABILITY

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Abstract
The environmental Kuznets curve (EKC) analysis is an important environmental indicator tool and exhibits an inverted U-shaped curve between a specific measure of environmental pollution and per capita income levels. Environmental pollution risk parameter is inorganic fertilizer use in this study. Current study ascertains a Critical Environmental Risk Threshold (CERT) value by considering basic variables, such as the amount of long term, total groundwater; the amount of arable land; the nitrate vulnerable zones; and the withdrawal rates for investigated countries. The value of the CERT might supply researchers and policy-makers with new insights with which to determine whether countries surpass their turning points below the CERT. Results indicates that use of inorganic fertilizer use in the Netherlands and Germany surpass their turning points above their CERT values.

Key words: Critical environmental risk threshold, Environmental Kuznets curve analysis, value of agricultural production, inorganic fertilizers

Introduction
This paper analyzes the environmental risk that can arise from inorganic fertilizer use that is linked with gross agricultural production value found in selected countries between 1961 and 2009. Environmental Kuznets Curve (EKC) analysis can help us to understand the relationship between the variables that is investigated (Gürlük, 2009; Panayotou, 1993)). The excessive use of inorganic fertilizers, which creates considerable concern among the world countries, and calls for the design of several environmental policies to resolve the loss of fertilizer from the soil.

This paper contributes to the existing literature for various reasons. Until recently, an environmental risk parameter, such as inorganic fertilizer use has not been considered in the EKC studies. (Khanna and Plassmann, 2004) performed studies using the parameters of sulfur dioxide (SO_2), particulate matter (PM_{10}), carbon monoxide (CO), ground level ozone (O_3) and nitrogen oxides (NO_x). However, their results did not provide evidence against the EKC hypothesis. (Gürlük, 2009) considered the levels of industrial pollution in coastal Mediterranean Countries and found that nearly all of the countries in the study, apart from France, have polluted the Mediterranean Sea. Additionally, human development should be the first objective of economic development in the southern countries of the Mediterranean; however, recommendations remain uncertain without an environmental risk threshold measurement. This study attempts to clarify such uncertainties in EKC studies with accessible data. (Managi, 2006) examined the pesticide risk with changing groups, such as human health and fish life. He used various methodologies, including the physical measurement of 200 pesticides that were applied to twelve crops. Yet, the fundamentals of the EKC hypothesis depend on time series data. Hence, many factors affecting risk thresholds can change over time. This study examines such shifts in a dynamic, economic system with European Union's (EU) environmental standards. (Diao et al, 2009) found that relationship between economic growth and environmental pollution in Jiaxing industrial region of China. Their model reveals an inverted U-shaped, an increasing linear and a weak N-shaped patterns for shifting polluter types. In other study carried out in China, impacts of foreign direct invests on environmental pollution were investigated through EKC analysis. Foreign direct invests have negative effect on environment (Haisheng et al, 2005). Yet, the question of what is the limit of this effect remain unanswered. Archibald et al, (2009) examined water quality indicators. Yet, two questions were unanswered at this study: what are the critical limit for selected pollution parameters, and which countries converge below the critical environmental threshold?

The parameter of "critical environmental risk threshold" (CERT) is asserted in the current study. Although the importance of the critical threshold was stressed in fundamental EKC reports, it was not possible to use it because the necessary data were not available. For instance, (Vehmas et al, 2007) examined material flows with economic growth in EU-15 countries. Their paper mentioned the carrying capacity of environment, but there is no evidence on how carrying capacity will be evaluated for selected polluter types in this study. The value of the CERT might supply researchers and policy-makers with new insights with which to determine whether countries surpass their turning points below the CERT.

Materials and Methods

Research material depends on long-term database of the Food and Agriculture Organization, FAO, of the United Nations. Data relating to socio-economic indicators were gathered from the database of World Development Indicators of the World Bank (WB, 2011). Investigated countries are the Netherlands, France, Germany, Spain, Italy, Turkey, China, India, Brazil, and the United States of America (USA). They are selected because either rural populations in the world scale or value of their gross agricultural production values. Parameters that are investigated in this study are inorganic fertilizer use, the VGAP, rural population pressure, which is calculated as rural population / agricultural land, number of tractors per agricultural area and the CERT value.

Inorganic fertilizers, nitrates, phosphorus and potassium, are key production inputs for raising yields in agriculture. Nitrates, phosphorus and potassium are essential to plant growth, but excessive levels of those fertilizers in the subsoil, caused by leaching, might cause environmental problems. The EU has implemented directives such as the Water Framework Directive, WFD, (2000/60/EC) and the Nitrates Directive (1991/676/EEC) to resolve issues of this type. In a study carried out in the Ebro Basin of Spain, (Lassaletta et al, 2010) stated that fertilizer leaching exists at serious levels, and it does not depend on the size of the catchments. In this basin area in Spain, they recommend that human activities affecting headwater streams should, therefore, be considered if the 2015 objective of the WFD is to be achieved.

The CERT is a comparison parameter that is identified in the EKC theory. Yet, it is not available in use because there are no recorded time series data for environmental indicators. In this study, CERT parameter, which can contribute to the EKC literature, is suggested. In calculating this parameter, two fundamental variables were used: the total amount of groundwater in a country and the EU Nitrates Directive standard. The EU Nitrates Directive confirms that nitrate concentrations must not exceed 50 mg/l liter to attain good ecological status in EU waters. By performing calculations with these variables, the maximum amount of fertilizer that countries are permitted to use in various years was accepted as a critical environmental risk threshold. Although the value of the CERT variable is permitted to vary according to different districts of a country, this parameter is important in understanding the larger issues surrounding the EKC debates.

The general assumption while calculating the CERT value is that countries' amounts of groundwater generally do not vary over time. Therefore, the maximum amount of fertilizer that is permitted in groundwater is clear in the EU Nitrates Directive and is easily determined in metric tons. The possible amount of fertilizer in groundwater can be calculated because the total amount of groundwater in a country is also made available and can be secured from the FAO database.

Polynomial regression models were employed to find evidence for the EKC relationship between the dependent and independent variables. The polynomial regression model can contain one, two, or more than two independent variables (Chen et al, 1972). Each independent variable can be presented in various powers. A second-order model with one independent variable is written as (Eq. 5):

$$Y_i = \alpha_0 + \alpha_1 x_i + \alpha_{11} x^2_i + \varepsilon_i \quad (5)$$

where $x_i = X_i - \bar{X}$. Note that the independent variable is expressed as a deviation around its mean $\bar{X}$, and that the i^{th} observation deviation is denoted by x_i. The reason for using deviations around the mean in polynomial regression models is that x, x^2 and higher-power terms often will be highly correlated (Neter et al. 1983). Expressing the independent variable as a deviation from its mean considerably reduces the multicollinearity. In the estimated second-order model, the maximum (minimum) occurs at the level x_m as (Eq. 6):

$$x_m = -a_1/2a_{11} \quad (6)$$

In terms of the original variable X, the maximum (turning point) occurs at the level of X_m as (Eq. 7):

$$X_m = X_{mean} - a_1/2a_{11} \quad (7)$$

In light of the above explanations, the following second-order polynomial model is estimated separately as (Eq. 8):

$$I_{it} = \alpha_0 + \alpha_1(G_{it}) + \alpha_{11}(G_{it})^2 + \alpha_2(T_{it}) + \alpha_3(R_{it}) + \varepsilon_{it} \quad (8)$$

where subscript i represents country and t represents year. Of the explanatory variables, G indicates value of gross agricultural production. The squared term of this variable tests the EKC hypothesis. T and R are other explanatory variables, which are technological change and rural population per agricultural area, respectively.

Results and Discussion

The second-order model, including four explanatory variables, were developed with SPSS© software to identify the factors behind the consumption of inorganic fertilizers. Table 2 reports the results of regression of the models, while Table 4 refers to the turning points of the second-order regression functions.

According to results, France and Brazil do not have an EKC relationship and consequently a turning point with respect to agricultural production. France and Brazil are important agricultural countries due to their share in the world agricultural production value. Both of these countries had about 6.5 percent of the world agricultural production. Variables of technologic change in France and rural population pressure in Brazil were statistically significant. A positive result for the technological change variable shows an increase in this variable. Furthermore it causes an increase in agricultural income and use of inorganic fertilizers. The negative population pressure in rural areas in Brazil variable may indicate that agricultural businesses are starting to merge and more industrial farms are emerging in the sector. Rural population increases are triggering a decrease on inorganic fertilizer use. As rural population decreases and industrial farming increase, a rise in inorganic fertilizer use can be expected.

All of remaining countries have EKC relationship, and have turning points (Table 3). Of those countries, the Netherlands and Germany surpassed their turning points above the CERT value. The two Mediterranean countries, Italy and Spain, generally can be accepted as green countries in terms of inorganic fertilizer use. Both countries have consumed less inorganic fertilizers than CERT value in their turning points. The value of gross agricultural production was the main determining factor of the turning point in Turkey, which has the lowest inorganic fertilizer use level in selected countries. Inorganic fertilizer use was 35 liters /ha at the turning point when reached at 1184 USD/ha of the VGAP. If we consider the high CERT value in Turkey, 200 liters /ha, inorganic fertilizing through controlled agricultural subsidies might supply increases in yields. It is

recommended that Turkey identify and declare seasonal fertilizing dates in previously nitrate-vulnerable zones. A stringent monitoring system might particularly oblige farmers to be sensitive to agricultural cultivation in the regions close to wetlands.

The VGAP variable has strong statistical significance in the USA. The USA is a country that uses the most inorganic fertilizer at its turning point. Yet, it is inferred from the results that the USA reached its turning point below the CERT value. In the USA, while the use of technology in agriculture increases it causes a decrease in inorganic fertilizer use. India and China like USA use a large amount of fertilizers this rate is not high in terms of per area use. 45% of the world fertilizer use belongs to these two countries. Similarly 45% of world rural population lives in these two countries. The turning points are under CERT value in both countries.

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Utilization Waste Spent RCC as Building Material in Making Interlock Block

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Abstract

Based on the previous research results that has been done by Research Institute for Human Settlements, Padjadjaran University Bandung, and State Polytechnic Bandung, known that spent residium catalytic cracking (spent RCC) completely more as pozzolan, so can functioned as substitution portland cement (PC) or as mineral admixture in concrete and mortar.

This research use waste material spent RCC as substitution PC, in making interlock block, used for house wall or building wall. Waste spent RCC taken from Pertamina UP VI Balongan Indramayu.

Until now not yet utilize spent RCC as building material commercially. On the other hand Pertamina as waste producer faced with problem how to manage the waste.

Benefits can be gained, including : (a) Spent RCC can be used as building materials that produced commercially ; (b) Avoid environment pollution, cause if has been mixed (bounded) become interlock block, then unsure was worried as B3 (hazardous material and poisonous) will not decompose (spread) as environment pollution.

Keywords
Spent RCC, waste, interlock block.

Introduction

Catalytic cracker is chemical engineering unit in oil refinery in which mineral oils with high boiling points are converted to fuels with lower boiling points by catalytic process.[1)]

Catalytic cracking is petroleum refining process that dates back to early 1915 however it came into prominence during the Second World War. There was need for and improved process that would provide higher quality and quantity products than brute force tactics used in thermal cracking. By applying newer, more advanced knowledge of chemistry and chemical reactions petroleum refining could produce better yields of gasoline with higher octane ratings than thermal cracking could ever hope to accomplish.[2)]

Catalytic cracking accomplishes this goal by cracking small ionic molecules, called carbocations, off of longer straight chain alkanes. These carbocations can reattach to alkane molecule to create iso-alkane which has required higher octane rating need in today's society. Catalytic cracking, as noted before, runs on relatively long straight chain alkanes and therefore the feedstocks usually consist of, light cycle oils and potentially heavy gas oils or light vacuum gas oils.[3)]

These types of oils have size necessary to be able to be cracked while still forming correct length range of alkane products. The primary goal of catalytic cracking is to increase the quantity of production of higher octane gasoline than could be done from straight run products or thermal cracking, however constituents such as kerosene, LPG, heating oil, and olefins are produced as well[4)].

Interlock block is material to build wall that have hooks to lock up movement due to pressure. Interlock block is further development style from concrete block by adding lips on certain sides as lock.[5)]

Interlock block has been developed and widely used abroad. In America and Canada known some kind of interlock block, including CMUs, Haener Block which is designed as mortarless interlock block. Then Verot Oaks Building Blocks, Inc. (VOBB), interlock block shaped quadrangle sized 6 x 6 inches are arranged to shape grid.[5)]

In Thailand there are SMART iBlock shaped like detachable toy. SMART iBlock not designed as material mortarless, for installation used mortar liquid with composition 1 part of PC, 2 part of sand and 3 part of water.[5)]

In Indonesia although rarely there are some product interlock block, including DURABLOCK and kiblock. DURABLOCK designed use little mortar, while kiblock has been designed as material mortarless.[5)]

Almost all products offer same excellence, among them : a) Ability to reduce heat and sound ; b) resistance to fire ; c) speed and ease to construction ; d) saving to use cement ; e) specific gravity lighter than brick ; f) non finishing.[5)]

But, the products that have sold in market there are no optimally able to withstand earthquake from two directions, parallel and perpendicular wall.[5)]

Interlock block is perforated concrete brick shaped rectangular sized length 60 cm, width 30 cm, and thick 7 cm. Both vertical sides is slot and tongue, while horizontal sides made flat, so can construct without mortar or structures not even would happen slit. Interlock block have weight ± 30 kg per piece, can bring or construct by 1 person.[6)]

The content of chemical unsure in RCC dominated by SiO_2 and Al_2O_3 that in mixture concrete indicate can add reactivity cement, stability concrete and producing gas so can create air cavities in concrete that can improve the workability. Total content 3 main unsure that is SiO_2 + Fe_2O_3 + Al_2O_3 more than 70 % so can categorized as artificial pozzolan material and can be used as an additional ingredient mineral on mixture concrete.[7)]

Addition material spent RCC in PC can accelerate bonding time, estimated the existence influence of unsure alumina that high in spent RCC so absorb water in mortar and drying process getting more rapid. This material very appropriate when used as additional material with the purpose to accelerate hardening time of concrete.[7)]

At RCC content 10 % obtained best viscocity mortar (plasticity) and could decrease (stiffness) at bigger RCC content. Estimated based on test to bonding time actually material RCC can accelerate bonding time so with addition material mortar will quick become increasingly stiffness marked with decline viscocity value.[7)]

From test to heavy volume, there is tendency that weight decrease with add spent RCC, caused spent RCC have weight content smaller than PC.[7)]

The biggest compressive strength, obtained at RCC content 10 %, at 28 days, means RCC content 10 % is optimal proportion.[7)]

From ultra sonic test, obtained the highest value at RCC content 10 %, indicates that in this condition is mixture that very compact and massive[7)]

Testing slurry fresh concrete using slump test obtained best slashy value at RCC content 20 %, estimated there is influence content coarse aggregate that have water absorption relatively smaller than sand. Besides that probability gravel have heat hydration absorption bigger so can avoid hardening at mortar.[7)]

From test to air content at fresh concrete obtained that the level of air content will increase by add RCC content. Caused reaction RCC besides causing heat hydration also can produce gas, so it became cavity on concrete cause decrease of weight.[7)]

Similarly on the contrary, weight content will decrease by add RCC content, parallel with test results of air content.[7)]

LKA (waste catalyst original RFCC /without refining) have broad advance specific 2,373 cm^2/gr that approach minimum requirement cement determined as much as 2,800 cm^2/gr (ASTM C150-97), and added after receive treatment refining /ball mill 70 RPM LKB (waste catalyst RFCC ball mill 70 RPM /smoothened), that is 3,816 cm^2/gr exceed minimum requirement broad advance specific PC, while fineness modulus LKA and LKB each as much as 0.292 and 0.018 not fulfill requirements as fine aggregate for concrete, ASTM C33-93 requires fineness modulus fine aggregate between 2.3 until 3.1.[8)]

Refining 70 RPM not give effect to other physical properties. Water content value for LKA and LKB each 1.81 % and 1.92 % fulfill requirements pozzolan material as mineral admixture concrete, according to ASTM C618-97, maximum 3 %. Inspection test organic content, show that catalyst traces fulfill requirements as material mixing concrete.[8)]

Chemical analysis result has been done to waste catalyst original shows total content SiO_2 + Al_2O_3 + Fe_2O_3 as much as 97.92 %, fulfill requirements as mineral admixture (minimal 50 %), with content SiO_2 64.7 %, content Na_2O and SO_3 fulfill requirements ASTM C618-97 as mineral admixture of concrete.[8)]

Index activity compressive strength mortar use PC, for LKA at age 7 days and 28 days, fulfill criteria ASTM C618-97, that requires at least 75 %, while the need of mixed water obtained as much as 112 %. That value still fulfill pozzolan requirements for class N (natural kind of pozzolan). The size need of mixed water predicted by the size of absorption LKB.[8)]

Refining LKA by ball mill 70 RPM (revolution per minute) for six hours, that change fineness value (broadly surface specific Blaine) from 2,373 cm^2/gr to 3,816 cm^2/gr, give real impact to increase index activity compressive strength at age 7 days and 28 days, each as much as 3.7 % and 17.6 %. According to Bouzoubaa (1998), with refining pozzolan (fly ash) for 4 hours increase compressive strength 5 % - 27 %. While the need of mixed water caused refining reduced from 112 % to 107 % or occur decrease as much as 4.5 %. This shows that refining pozzolan in certain time give influence to reactivity as additional material (mineral admixture) in mixture mortar or concrete, and this is just indicated refining increase quality pozzolan especially waste catalyst as additional material (mineral admixture) to reduce the number of usage PC. This results conclude that waste catalyst have characteristics pozzolan active.[8)]

In 1991, Balongan, Indramayu chosen as the location of refinery named the refinery project EXOR I (Export Oriented Refinery I). The operation of the oil refinery at further development changed the name to PERTAMINA UP VI (UP = Unit Production) Balongan. Startup this refinery done in October 1994, but just inaugurated on 24 May 1995 by President Soeharto, after suffered a setback of first schedule 30 January 1995.[9)]

Crude oil processed at the refinery it is crude oil spines (50 %) and minas (50 %) and natural gas from east part of West Java as much as 18 Million Metric Standard Cubic Feet per Day *(*MMSCFD) product was produced by Pertamina UP VI Balongan among other : motor gasoline, kerosene, industrial diesel fuel, propylene, LPG, decant oil, and fuel oil. There are main process in UP VI Balongan that can be divided into two, that is[9)] :

- Unit Distillation and Hydro Treating Complex (DHC)
  In this unit consisting of Distillation Treating Unit (DTU), Atmosferis Residu Hydrodemetalization Unit (AHU), and Hydro Treating Unit (HTU).
- Unit Residu Catalytic Complex
  In this unit consisting of Residu Catalytic Cracker Unit, Unsaturated Gas Plant, LPG Treatment, Gasoline Treatment Unit, Propylene Recovery and Catalytic Condensation Unit.

This unit functioned as oil refinery advanced level (secondary processing) to get added value from residue processing that is mixture from DMAR product ARDHM and AR product CDU by development use catalyst. Reduced crude as bait RCC is mixture of paraffin, olefin,

naphtene, and aromatic that very complex is fraction series start from gasoline in small quantities until fraction heavy with the number of atom C long.[9)]

The resulting products among other[9)] :
- Liquified Petroleum Gas (LPG)
- Gasoline from naphta fraction
- Light Cycle Oil (LCO)
- Decant Oil (DCO)

In RCC there is reactor, regenerator, catalyst condenser, main air blower, cyclone, catalyst system, and CO boiler. This unit closely related to Unsaturated Gas Plant Unit that will manage main product of main column RCC Unit being stabilized gasoline, LPG and non condensable lean gas.[9)]

While stream was not produced among other[9)] :
- Heavy naphta
- Heavy Cycle Oil (HCO)

Product bottom DCO sold to Japan, used to Independent Power Plant for power plant, and used for carbon black. Other products sent to LEU for processed further.[9)]

RCC was designed to cultivate Treated Atmospheric Residue derived from AHU unit with design 29,500 BPSD (35.5 % volume) and Untreated Atmospheric Residue derived from CDU unit with design 53,000 BPSD (64.5 % volume). Then mixed the two kinds of residue. Installed capacity is 83,000 BPSD.[9)]

Reaction that happens in this unit is cracking reaction (by catalyst and thermal). Thermal cracking occur through the establishment of free radicals, while catalytic cracking through the formation of ion carbonium tertiary. Cracking reaction is exothermic reaction. Catalyst was used consist of zeolit, silica, etc. One of the function of the acid part of catalyst is to break up large molecules.[9)]

Methodology

Interlock block sized 60 cm x 30 cm x 7 cm.

Interlock block using materials :
- Portland cement (PC) ;
- spent RCC ;
- sand ;
- conplast (additive) ;
- water.

The tools that used for making interlock block :
- Mixer ;
- interlock block multimoulding mold ;
- palette triplex for base mould results ;
- sieve ;
- compressive strength testing machine.

Mixture composition of interlock block :

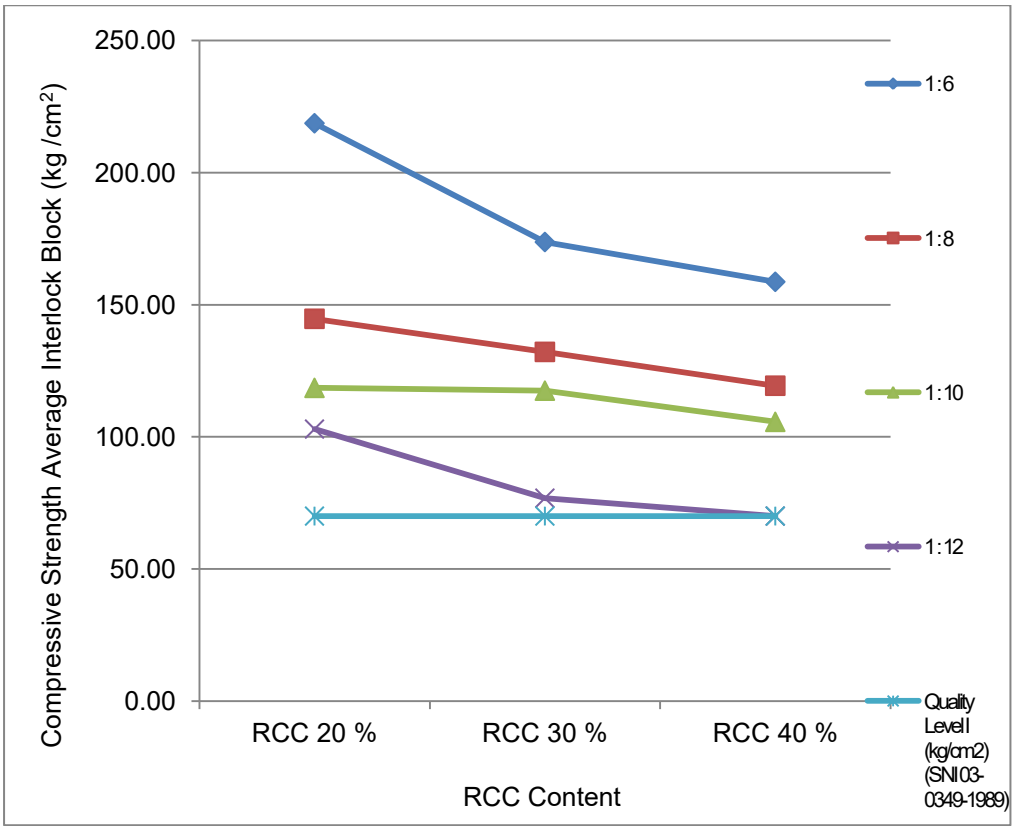
- Code A1 = 1 part (80 % PC : 20 % spent RCC) : 6 part sand : 1 % conplast (to volume PC) : 5 % water (to volume PC). Measurement using % volume.
- A2 = 1 (70 % PC : 30 % spent RCC) : 6 sand : 1 % conplast : 5 % water.
- A3 = 1 (60 % PC : 40 % spent RCC) : 6 sand : 1 % conplast : 5 % water.
- B1 = 1 (80 % PC : 20 % spent RCC) : 8 sand : 1 % conplast : 5 % water.
- B2 = 1 (70 % PC : 30 % spent RCC) : 8 sand : 1 % conplast : 5 % water.
- B3 = 1 (60 % PC : 40 % spent RCC) : 8 sand : 1 % conplast : 5 % water.
- C1 = 1 (80 % PC : 20 % spent RCC) : 10 sand : 1 % conplast : 5 % water.
- C2 = 1 (70 % PC : 30 % spent RCC) : 10 sand : 1 % conplast : 5 % water.
- C3 = 1 (60 % PC : 40 % spent RCC) : 10 sand : 1 % conplast : 5 % water.
- D1 = 1 (80 % PC : 20 % spent RCC) : 12 sand : 1 % conplast : 5 % water.
- D2 = 1 (70 % PC : 30 % spent RCC) : 12 sand : 1 % conplast : 5 % water.
- D3 = 1 (60 % PC : 40 % spent RCC) : 12 sand : 1 % conplast : 5 % water.

Process manufacturing interlock block :

- Sieve sand until have gradation homogen, that is loss sieve 1 cm ;
- Weighing materials (PC, sand, spent RCC, conplast, and water) according to mixture composition ;
- Mix the materials use mixer until homogen ;
- Insert the mixture into multimoulding mould interlock block until solid ;
- Before that, give oil to inside part of multimoulding mould, so make easy to release mixture mortar from mould ;
- Let mixture mortar inside mould until ± 30 minute or until dry so easy to release from mould ;
- Release interlock block from mould ;
- Put interlock block in dry place ;
- Compressive test interlock block in laboratory.

Resesarch Result

Figure 1. Comparison between RCC content to compressive strength average interlock block



Add more spent RCC as substitution cement, then more decrease compressive strength average interlock block has produced. This is because spent RCC is waste from processing oil fuel, the potential big enough (10 – 16 tons per day). More completely pozolan, so can functioned as substitution PC or mineral admixture in concrete and mortar. When mixed (bounded) become interlock block, then unsure B3 that there were concerns will not dissolved (scattered) as environment pollutants. Chemical unsure in RCC dominated by SiO_2, Fe_2O_3 and Al_2O_3, in concrete can increase reactivity characteristics of PC, stability concrete and workability.

To build healthy simple house use interlock block as wall component, very helpful in building process (erection), besides the time for build is relatively short (2 weeks), also the raw material that needed relatively little. It is especially affected by the shape and size.

A measure of interlock block relative large (60 cm x 30 cm x 7 cm) so to construct per piece become fast, but in thickness only 7 cm, so can bring or construct by 1 person. Weight per piece ± 30 kg.

The form of interlock block is two vertical side is slot and tongue, so constructed without mortar /space did not cause crack. If necessary reinforcement, then at the holes can put pegs from wood or from pipe PVC (polivynil chloride). But need to be records, with shape slot and tongue at the four sides cause difficult enough to get straightness and precision at construction time.

Total population Indonesia in 2015 is 252,370,792 people. Total house in Indonesia in 2015 is 45 million unit, total new house need 1.4 million house every year.[10)]

To build 1 unit house type 36 need ± 432 pieces interlock block. In all regions in Indonesia every year need 1.4 million house. Assumption if the whole house built is type 36, then need 604,800,000 pieces interlock block, to build 1.4 million house type 36.

Interlock block sized 60 cm x 30 cm x 7 cm. To produce 1 piece interlock block, in this case interlock block with highest compressive strength 218.67 kg/cm^2, optimal mixture composition : 1 part (80 % PC : 20 % RCC) : 6 part sand, need 3.25 kg PC ; 0.82 kg RCC ; 0.714 m^3 sand.

Spent RCC is waste from processing oil fuel have potention big enough, reach 10 – 16 tons per day, means in 1 month can reach at least 3,000 ton or at least 36,000 ton per year. If 1 piece interlock block need ± 0.82 kg spent RCC, means potency spent RCC in 1 month enough for produce ± 3,658,537 pieces interlock block /month, or potency spent RCC in 1 year enough for produce ± 43,902,439 pieces interlock block /year, sized 60 cm x 30 cm x 7 cm with mixture 1 (80 % PC : 20 % RCC) : 6 sand.

The price of one interlock block use spent RCC is Rp. 12.200,- while the price of lightweight brick in market is Rp. 12.500,- /piece. So the price for produce interlock block use spent RCC still cheaper than the price of lightweight brick that have sold in market.

Conclusion

Interlock block use spent RCC as much as 20 %, 30 %, or 40 % have compressive strength more than quality I according to SNI 03-0349-1989 about concrete block. So interlock block use spent RCC can continue to produce, to develop, and to sell in market, more over to use by societies, as building material for housing building component.

The highest compressive strength 218.67 kg/cm^2, optimal mixture composition : 1 part (80 % PC : 20 % RCC) : 6 part sand.

To fulfill all house needs in Indonesia, every year need 604,800,000 pieces interlock block, so need 1,965,600,000 kg PC or 39,312,000 zak PC content 50 kg ; 495,936,000 kg spent RCC = ± 2,479,680 m^3 spent RCC ; 431,827,200 m^3 sand.

The price of interlock block use spent RCC cheaper than the price of lightweight brick that have sold in market.

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Utilization Waste Wood Shavings in Making Hollow Panel

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Abstract

This research is to know how much waste wood shavings can be utilized as raw materials for wall component in the form of hollow panel, in making house, for help the society and the government in anticipate surplus housing needs, so for minimalization waste wood shavings that if not utilized will more and more pile up and make environment pollution. Also to know how much cost needed if make hollow panel, compare with wall component that sold in market.

The laboratory test results show compressive strength hollow panel fulfill requirements Indonesian National Standard (SNI) no. 03.3122-1992 “Fibrous Lightweight Concrete Panel”, towards quality A or quality B, for utilization waste wood shavings with content 20 % or 30 %.

Keywords
Waste wood shavings, hollow panel, wall component.

Introduction

Research results about utilization waste wood shavings :

- This research developed sawdust waste (wood flour) to become particle board. To support this research have to be made press equipment laboratory scale. The wood waste characteristic and particle board parameter become guidance in production press equipment. The particle board dimension that press equipment produce is height 300 mm, width 200 mm, thick 20 mm. Urea formaldehide glue was chosen in this research, because it cheaper than phenol formaldehide or melamine formaldehide, and for its transparent. Process production particle board using 10 % and 15 % for variation of glue percentage also 3 days and 7 days for oxidation time. In this research is the way to introduce the process and engineering of technology of waste utilization in to environment, specially for wood flour utilization to be particle board. The result of this research show that, the engineering of technology of waste utilization is one of the effort to improve an environment quality and wood waste utilization to be particle board to improve the commercial value of wood waste. The particle board producted is indication of an equipment work capability and a mastery of technology in the particle board production process.[1)]
- This research to know whether sawmill waste can utilized as mixing material in making blocks to reduce weight and refine blocks. Production blocks with any sample was made by add sawmill waste to mixture concrete with different precentage that is 5 %, 10 %, 15 %, 20 %, 25 %, and 30 %. The sample test shaped block with mixture composition 1 cement portland (PC) : 6 sand. After age 28 days, weighing and push test the sample test block cubes.[2)]

Waste wood shavings is residue of wood production process, often throw away, even inclined pointed as something damage. Eventhough reuse, more used for pile of soil or for energy. That also sometimes make difficult and make pollution for environment. In other side, cost for build house become more and more expensive cause increase cost of building material.

For that reason, this research is to utilization waste wood shavings as building material in making hollow panel to building component for housing.

Three kinds of wood waste such as slight shavings, chips shavings, and dust, can used as mixture to produce wall component. But as usually biomass, that wood waste still contain lignocellulose shaped glucose, tannin, and oil, that can disturb process hardening cement. For that content lignocellulose must minimalized first until 1 % - 3 % before mixed with cement and sand for bonding mixture that good and homogen. For that need to treatment, such as : oxidation, waterproofing, alkali, and accelerator. For this research choose very simple way that is by oxidation way, by soak in lime water by lime content 20 % as long as 12 hours.

Hollow panel sized 240 cm x 60 cm x 8 cm, using waste wood shavings.

That size effect to the weight, 90 kg for one hollow panel, that make difficult to handle and construction. To take and construct every panel need four people. This problem can anticipate by add additive at mixture until mortar become lighter, or by change sand with fine aggregate from float stone, or add admixture shaped gases.

Two vertical sides (length sides) shaped slot and tongue as function to close between panel vertical way.

Technical production for scale up (mass production) hollow panel can mould by manual use single mould, use shaking table and vibrator.

SNI about wall component " Fibrous Lightweight Concrete Panel" SNI 03-3122-1992, concrete panel categorized hollow if wide hollow more than 25 % wide surface panel.

Particle board is board that made from particle wood or other material lignocellulose that bonded by organic glue and by supply one or more heat unsure, compression, moisture, catalyst, and so on ((Iskandar,2006).

Particle board is little part that made from pieces wood that produced by cut or mechanical fracture. Particles that connect each other by synthetic glue dominated synthetic material. Additive unsure such as paraffin often inserted to resin wood mixture for give stability dimension or physical properties needed to particle board. Particle wood that was used produced from residue other primary wood or from spherical wood. Combination raw material process production particle such as result in any shape and size particle (Tsoumis, 1991).

Quality particle board include defect, size, physical properties, mechanical properties, and chemical characteristics. In standard about particle board was published by any country still possible any differences in case criteria, testing method, and requirements. Nevertheless, the point is same.

In Indonesian Standard 1983 no separation quality particle board based on defect, but in standard 1996 any four quality performance particle board according to defect, is : A, B, C, and D. The defect that pointed is coarse particle at surface, spot of dirt shavings, spot of dirt oil, scratch, spot of dirt glue, broken on sides, and have hole inside.

Maloney (2003) in Iswanto (2005) particle board is one kind product composite wood panel that made from wood particles or other lignocellulose material, that bonded by glue or other bonding material than hot press. Based on density, particle board can separated into 3 groups:

- Low density particle board, that is particle board have density less than 0,4 gr/cm^3.
- Medium density particle board, that is particle board have density between 0.4 – 0.8 gr/cm^3.
- High density particle board, that is particle board have density more than 0.8 gr/cm^3.

Handayani (2001), beneficial particle board is :

- fire resistant ;
- weather resistant ;
- resistance to insect and termitiside attack ;
- resistance to fungi ;
- sound absorption ;
- easy to handle ;
- have strong structure ;
- stability dimension ;
- no poisonous.

Methodology

In making hollow panel using materials :

- Portland cement (PC) ;
- sand ;
- waste wood shavings ;
- conplast (additive) ;
- water ;
- lime.

The tools that used in making hollow panel :

- Mixer ;
- mould hollow panel ;
- pallet triplex ;
- sieve ;
- compressive test machine.

Mixture composition that used in making hollow panel, is : 1 part PC (% volume) : 8 part sand (% volume) : 30 % waste wood shavings (to volume PC) : 1 % conplast (to volume PC) : 5 % water (to volume PC).

Process production hollow panel :

- Before using, waste wood shavings soaked in lime water solution (5 % from volume water), to make dissapear sugar content in waste wood shavings.
- Sieve sand until have gradation homogen, that is loss sieve 1 cm ;
- Weighing materials (PC, sand, waste wood shavings, conplast, and water) according to mixture composition ;
- Mix the materials use mixer until homogen ;
- Insert the mixture into mould hollow panel until solid ;
- Before that, give oil to inside part of mould, so make easy to release mixture mortar from mould ;
- Let mixture mortar inside mould until ± 30 minute or until dry so easy to release from mould ;
- Release hollow panel from mould ;
- Put hollow panel in dry place ;
- Compressive test hollow panel in laboratory.

Analysis and Discussion

Laboratory test results show compressive strength hollow panel fulfill requirements SNI no. 03.3122-1992 for fibrous lightweight concrete panel such as in table 1 :

Table 1. Laboratory Testing Results Hollow Panel

Mixture Composition	Waste Wood Shavings (%)	Compressive Strength (kg /cm^2)	
		Average Test Results	SNI
1 PC : 8 sand	20	65,39	Quality A : 44,4
	30	65,49	Quality B : 34,5

From laboratory test results compare with requirements SNI 03.3122-1992, even to quality A or quality B, composition that was used have fulfill the requirements, for use waste wood shavings 20 % or 30 %.

Indonesia population in 2015 amount 252,370,792 people. Total house in Indonesia in 2015 is 45 million unit, total new house need 1.4 million house every year.

To build 1 unit house type 36 need ± 77 pieces hollow panel. In all regions in Indonesia every year need 1.4 million house. Assumption if whole house built is type 36, then need 107,800,000 pieces hollow panel, to build 1.4 million house type 36.

Hollow panel sized 240 cm x 60 cm x 8 cm. To produce 1 piece hollow panel, in this case hollow panel with highest compressive strength 65.49 kg/cm^2, optimal mixture composition : 1 part PC : 8 part sand : 30 % waste wood shavings, need 19.20 kg PC ; 153.60 kg sand ; 5.76 kg waste wood shavings.

Waste wood shavings achieve 1.4 million m^3 every year. If 1 piece hollow panel need ± 5.76 kg waste wood shavings, means potency waste wood shavings in 1 year enough for produce ± 48,611,111 pieces hollow panel /year, sized 240 cm x 60 cm x 8 cm.

The price of one hollow panel use waste wood shavings is Rp. 200.000,- while the price of triplex width 3 mm = Rp. 40.000,- ; width 4mm = Rp 50.000,- ; width 6mm = Rp 65.000,- ; width 9mm = Rp 100.000,- ; width 12mm = Rp 135.000,- ; width 15mm = Rp 175.000,- ; width 18mm = Rp 195.000,- ; GRC board = Rp. 50.000,-.

The price of cement fiber board (GRC), that is merk Big Flat Elephant (120×200) width 9mm = Rp 47.000,- ; merk Big Flat Elephant (122×244) width 4mm = Rp 44.500,- ; merk Big Flat Elephant (122×244) width 6mm = Rp 72.000,- ; merk Big Flat Elephant (122×244) width 8mm = Rp 98.000,- ; merk Wood Plank Elephant (4050×100) width 8mm = Rp 50.000,- ; merk Wood Plank Elephant (4050×200) width 8mm Rp 65.000,- ; merk Wood Plank Elephant (4050×300) width 10mm = Rp 75.000,-.

Conclusion

Hollow panel use waste wood shavings as much as 20 % or 30 %, have compressive strength more than quality A according to SNI 03.3122-1992 about fibrous lightweight concrete panel. So hollow panel use waste wood shavings can continue to produce, to develop, and to sell in market, more over to use by societies, as building material for housing building component.

The highest compressive strength 65.49 kg/cm^2, optimal mixture composition : 1 part PC : 8 part sand : 30 % waste wood shavings.

To fulfill all house needs in Indonesia, every year need 107,800,000 pieces hollow panel, so need 2,069,760,000 kg PC or 41,395,200 zak PC content 50 kg ; 16,558,080,000 kg sand ; 620,928,000 kg waste wood shavings.

This hollow panel still more expensive compare with the price of triplex with width very thick, Rp. 195.000,-. But this hollow panel have compressive strength more than standard quality A or quality B.

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Why Green IT is an Excellent Topic for STEM and STEaM Projects

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Abstract:
Green IT (Information Technology) is an excellent project for both STEM (Science, Technology, Engineering, and Mathematics) and STEaM (STEM + arts). That's because all students are familiar with Information Technology (IT) through the use of their PCs, laptops, iPads, smart phones, and all the social media used with those devices. Thus energy efficient IT (or Green IT), is an area that is bound to grab their interest, no matter whether they are interested in technical fields or the arts. Also, almost all schools in the U.S., and most schools worldwide, use IT as a tool with their instruction.

An important aspect of a STEM/STEaM project with Green IT would be data centers. Data centers are found in nearly every sector of the economy including financial services, media, high-tech, universities, and government institutions. Dramatic server growth at data centers is indicated by well-known web services such as Google, Amazon, and eBay. Estimates indicate that Google maintains over 2 million servers, arranged in racks located in clusters in cities around the world. There are also many thousands of servers for Amazon.com and eBay. Even with these large numbers of current servers, IDC estimates that in the next decade the number of servers will grow by ten times and data storage by an amazing 50-fold.

Green energy efficient IT will help us reduce greenhouse gases - which in turn will help reduce global warming. The ongoing UN and White House sessions on climate change emphasize the environmental importance of green projects. Although the extent of the Global Warming danger may continue to be open to debate, implementing Green IT presents a significant opportunity for all of us to help reduce greenhouse gasses. This paper includes case studies based on the author's experiences with energy efficient computing and experiences discussing Green IT with STEM and STEaM students.

Keywords - green IT; STEM; STEaM; carbon footprint; mobile computing; cloud computing

1. Introduction

When I mentioned to my music major niece a year ago that I was working in the STEM area, she said that she and her music major friends wanted that changed to "STEAM" to include the arts [17]. At the time, I thought she was kidding. I know better now. It turns out that Green IT is both a great STEM project and a great STEaM project. Of course, science and arts have always gone together. The great Renaissance man, Leonardo da Vinci, is famous both as an inventor and scientist and as a great artist and would certainly be an advocate of STEaM. In our current age of computers and electronic devices, technology and design are very much connected. Steve Jobs, the Apple founder, was more into design than technology. He left the technology details to the "other Steve" (Steve Wozniak). Elon Musk, who launched Tesla electric automobiles, is another modern day Renaissance man who is in the STEaM group. Design and energy efficiency are very much a part of Tesla cars and Musk's SpaceX reusable rockets for launching commercial satellites and even for getting adventurous people to Mars [15]. Musk is also helping create green electric energy through his Solar City venture. STEaM collaboration is also very important for green IT since there is a great need both for design (arts) and technology in making Information Technology green.

There are many aspects of green IT. The energy used for green IT is electricity, so students must become familiar with the basic electricity concepts and relationship of volts, amps, and watts, which are all fundamental in our quest to reduce energy used for green IT. The relationship between volts, amps, and watts is this: watts = volts x amps. A watt is the measure of electrical power. Energy is power over a unit of time. We pay for electricity in terms energy used with a measure of kilowatt hours or KWH. One kilo watt hour (KWH) of electrical energy is the energy used by having 10 one hundred watt light bulbs on for one hour. In the New York City area one KWH costs about 20 cents while in West Virginia a KWH costs only about 6 cents. The big difference is due to the big difference in generation costs.

Besides the cost per KWH, another aspect of basic electricity to consider, especially for data centers, is the voltage level. In the U.S. we typically have two voltages to use in our homes, offices, and data centers, 120 volts or 240 volts. The actual volts can fluctuate somewhat during the day (as you can discover using a simple voltmeter). If you have an electric range, an electric clothes dryer, or a large electric air conditioner in your home, they'll be connected to the higher 240V service. The reason is that these appliances need more power; using a higher voltage gives more power and also saves energy. Higher voltage saves energy since the formula for electric losses due to transmission over a wire is I2 R where "I" represents amps and R is the fixed resistance of the wire. Since watts = volts x amps, we can double the power (watts) by doubling the volts or doubling the amps. However, doubling the amps would increase the losses by four times. Thus, to transmit electricity over long distances, the practice is to increase the voltage as much as possible. In high tension towers the voltage is often as high as 120,000 volts and even in the power lines outside our houses the voltage is usually 4,000 volts. That voltage drops to 120V for use in our houses to reduce danger of electrocution. As noted, 240V power is used only for electric ranges, clothes dryers, etc., although in Europe the base power is 240V. One easy way to reduce energy transmission losses at data centers is to use 240V service. Higher input voltage results in more efficient operation. Most servers (just like our laptops or hair dryers) are capable of either 120V or 240V service. Older data centers often have 120V power sources for servers, though switching to 240V would provide significant savings.

For this paper we'll follow this Outline:

1. Introduction
2. The Growing Significance of Green IT and Green Data Centers
3. Green IT is more than Data Centers – Your Laptop is Included

4. The Significance of Virtualization and Cloud Computing in Green IT
5. STEaM, STEM, Healthcare, and Green IT
6. Ways to promote STEM and STEaM Green Initiatives
7. New Technology for Green IT
8. Conclusions

2. The Growing Significance of Green IT and Green Data Centers

Data centers consume much more energy per square foot than any other part of an office building. Figure 1 shows the distribution of space and energy costs at IBM buildings [2]. Although data centers are less than 5% of the space cost at IBM, they account for almost 50% of the energy cost.

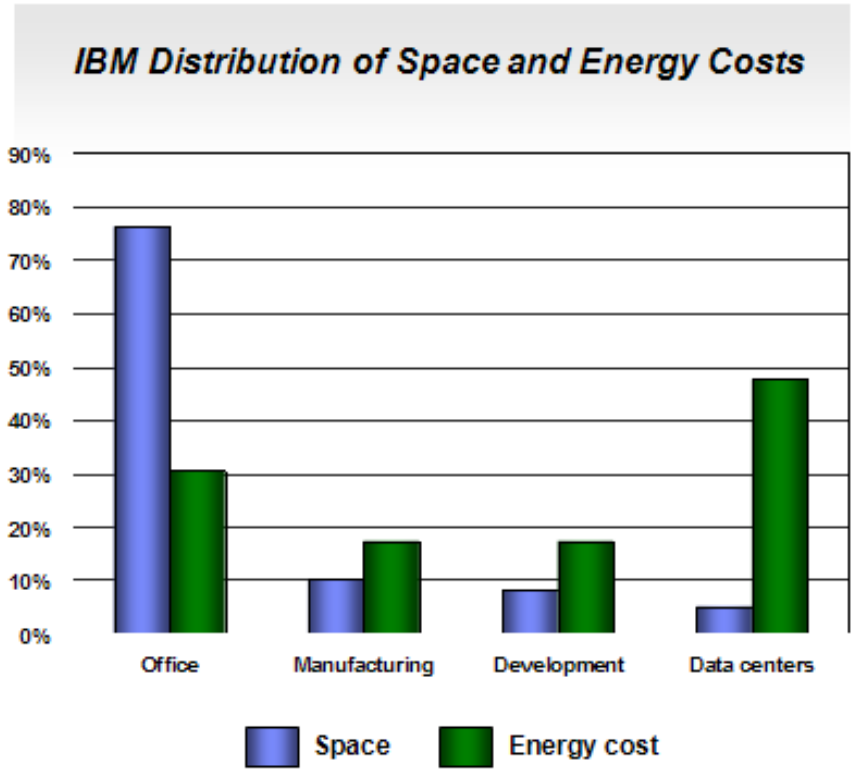

Figure 1. IBM Distribution of Space and Energy Costs (Source: IBM Corporate Environmental Affairs, Year end 2010)

A recent study at a major bank indicated that data centers accounted for just 1% of the bank's physical infrastructure space but consume about 25% of the power. So, there is a great deal of financial incentive to create green data centers.

The STEM and STEaM students will need to understand the basics on data centers since data centers house the servers that students access when they use Google, Facebook, or any of the many Internet applications used by all users, young and old.

Data Centers – the facilities that primarily contain electronic equipment used for data processing, data storage, and communications networking – have become common and essential to the functioning of business, communications, academic, and governmental systems. Data centers have been growing and expanding very quickly as our economy continues to shift from paper-based to digital information management. The US EPA's 2007 "Report to Congress on Server and Data Center Energy Efficiency" estimated that the energy use of the nation's servers and data centers

doubled from 2000 to 2006 to about 61 billion KWH [4]. Under current efficiency trends, national energy consumption by servers and data centers is projected to be more than 140 billion KWH by 2020, representing over $13 billion annual electricity cost.

Data centers are found in nearly every sector of the economy including financial services, media, high-tech, universities, and government institutions. Dramatic server growth at data centers is indicated by well-known web services such as Google, Amazon, and eBay. Estimates indicate that Google maintains over 2 million servers, arranged in racks located in clusters in cities around the world. Google has major data centers in California, Virginia, Georgia, Ireland, and new facilities in Oregon and Belgium. In 2009 Google opened one of its first sites in the upper Midwest in Council Bluffs, Iowa, close to abundant wind power resources for fulfilling green energy objectives and proximate to fiber optic communications links. There are also hundreds of thousands of servers for Amazon.com and eBay. In 2013, Microsoft reported that they have over one million servers at their datacenters. Even with these large numbers of servers, in 2011 IDC estimated that in the next decade the number of servers will grow by ten times and data storage will grow by an amazing 50-fold [18].

Green energy efficient data centers will help us reduce greenhouse gases – which in turn will help reduce global warming. The ongoing UN and White House sessions on climate change emphasize the environmental importance of green projects. Although the extent of the Global Warming danger may continue to be open to debate, implementing Green Data Centers presents a significant opportunity for all of us to help reduce greenhouse gasses.

3. Green IT is More Than Data Centers – Your Laptop is Included

It is important to remember that green IT also includes your laptop. When traveling with a laptop, we always need to be concerned about battery life. So we happily configure the power management functions to power off the screen after 15 minutes and let the laptop go to "sleep" mode after 30 minutes of inactivity. Our motivation is to conserve the battery when we're not "plugged in". However, use of "sleep mode" is a good green computing practice. Universities, often being on the forefront of concern for the environment, frequently have a green computing section on their websites (just Google "green computing at universities" and you'll see the hits). Here's some relevant information on green computing for desktop PCs and laptops at the University of Colorado (CU) web site
http://www.colorado.edu/oit/software-hardware/it-energy-conservation and used here by permission [4].

The growing use of computers on the University of Colorado campus has caused a dramatic increase in energy consumption, putting negative pressure on CU's budget and the environment. Each year more and more computers are purchased and put to use. Over the past twenty years, computers have transformed the academic and administrative landscape at the University of Colorado. Based on an energy study in 2008 there were over 18,000 computers on campus. Personal computers (PC) operation alone may directly account for nearly $550,000 per year in University energy costs. Computers generate heat and require additional cooling, which adds to energy costs. Thus, when the cooling requirement is added, the overall energy cost of personal computers at CU is more likely around $700,000 per year. But it's not just the number of computers that is driving energy consumption upward: the way we use computers also adds to the increasing energy burden. Research reveals that most personal desktop computers are not being used most of the time they are running, and many personal computers nationwide are needlessly left on continuously. Every time we leave computers or lights on we waste electricity. As we must constantly remind ourselves, these fuels emit pollutants, sulfur, and carbon dioxide into the air. These emissions can cause respiratory disease, smog, acid rain and global climate change.

Here's another challenge: meeting computer cooling needs in summer (and winter) often compromises the efficient use of building cooling and heating systems by requiring colder fan discharge temperatures. In the summer, these temperatures may satisfy computer lab cooling needs while overcooling other spaces. Given CU's commitment to energy conservation and the environmental stewardship, the University must address the issue of responsible computer use. By adopting conserving practices, the University can save $300,000-400,000 annually.

A. How Much Energy Does Your Laptop Computer System Use?

A typical desktop PC system is comprised of the computer itself (the CPU or the "box"), a monitor, and printer. Your CPU may require approximately 100 watts of electrical power. Add 50-150 watts for a 15-17 inch monitor, proportionately more for larger monitors. The power requirements of conventional laser printers can be as high as 100 watts or more when printing though much less when idling in a "sleep mode." Ink jet printers use as little as 12 watts while printing and 5 watts while idling.

How a user operates the computer also factors into energy costs. First let's take the worst case scenario, continuous operation. Assuming you operate a 200 watt PC system day and night every day, the direct annual electrical costs would be more than $125 (at $0.075/KWH). In contrast, if you operate your system only during normal business hours, say 40 hours per week, the direct annual energy cost will be about $30 - plus, of course, the cost of providing additional cooling.

Considering the tremendous benefits of computer use, neither of the above cost figures may seem like much, but think of what happens when these costs are multiplied by the many thousands of computers in use at, say, CU. The energy waste dollars add up quickly.

B. Energy Efficient Desktop and Laptop Computing

Below are some tested suggestions that may make it possible for you to reduce your computer energy consumption by 80 percent or more while still retaining most or all productivity and other benefits of your computer system, including network connectivity.

- **Screen savers save no energy**

If screen-saver images appear on your monitor for more than 5 minutes, you are wasting energy! Screen-saver programs may save the phosphors in your monitor screen, but this is not really a concern with newer monitors, especially LCD screens. And screen savers do not save any energy. A screen saver that displays moving images causes your monitor to consume as much electricity as it does when in active use. These screen-saver programs also involve system interaction with your CPU that results in additional energy consumption. A blank screen saver is slightly better but even that reduces monitor energy consumption by only a few percent.

- **Enable power management features**

Thanks to the U.S. Environment Protection Agency (EPA), personal computer systems purchased today can be easy on energy. These "Energy Star" computers and monitors can be programmed to "power-down" automatically to a low power state when they are not being used. These efficiency gains can be achieved without any sacrifice in computing performance.

The EPA has estimated that providing all computers in the USA with "sleep mode" reduces their energy use by 60 to 70 percent - and ultimately saves enough electricity each year to power Vermont, New Hampshire, and Maine, cut electric bills by $2 billion, and reduce carbon dioxide emissions by the equivalent of 5 million cars.

How can we achieve such impressive savings? Follow these simple steps to access computer and monitor power management features for Macintosh and Windows.

Macintosh: From any application select the Apple menu. Select "System Preferences..." (OS X) or "Control Panels" (OS 9) and then click on "Energy Saver"

Windows: Point your cursor at the desktop background and right-click. Choose "Properties" from the pop up menu. Go to the "Screen Saver" page; in the lower right-hand corner near the ENERGY STAR® logo click the "Settings" button. This brings up another dialog box from which you choose power management settings.

The University of Colorado gives recommended settings of 20 minutes for monitor sleep and 30 minutes for system sleep. Remember that to save energy with your monitor's built-in power management system, your monitor must go to sleep (shut itself down). As a comparison, IBM recommends that employees use a setting of 15 minutes of inactivity to power off the monitor and 30 minutes of inactivity for system sleep mode.

- **"When not in use, turn off the juice"**

This is the most basic energy conservation strategy for any type of equipment. Consider the following:

1) Turn off your computer and/or peripherals when they are not in use. Turning on and off will not harm the equipment.
2) Don't run computers continuously unless they are in use continuously.
3) Always turn off at night and on weekends.
4) Look for ways to reduce the amount of time your computer is on without adversely affecting your productivity

- **You Can Turn Your Computer Off!**

The common misconception that a computer's life is shortened by turning it on and off has led some to leave computers on all the time. Others are reluctant to switch their computers on and off a couple times during their workday despite using this equipment for only a fraction of that time. Desktop computers are designed to protect the internal circuitry from power damage through on/off switching. Turning PC equipment off at night or on and off a few times a day will not appreciably affect its useful life. Electronic equipment life is a function of operating hours and heat; both these factors are reduced when equipment is switched off. Modern hard drives are designed and tested to operate reliably for thousands of on/off cycles.

Thus, you CAN turn off your computer (and monitor and printer)! The inconvenience of waiting a minute or two for a computer to reboot or peripheral to come on line may be trivial compared to the energy savings achieved by keeping computer equipment off when it's not in use.

Some specific suggestions:
Unless you require immediate access to e-mail or other Internet services, break the habit of turning on all your computer equipment as soon as you enter the office each day. If practical, informally group your computer activities and try to do them once or twice a day, leaving the computer off at other times.

1) Avoid using the switch on a power strip to turn on all your equipment.
2) If you use a laser printer, don't turn your printer on until you are ready to print.

3) Turn off your entire computer system (CPU, monitor and printer), or at least your monitor and printer, when you go to lunch or will be out of office for a meeting or an errand.
4) As for "computer servers" which must be on to serve network functions, explore ways to turn them off at night.
5) If monitors are not needed for "servers" to operate, keep server monitors off. If server monitor is needed during the day, at least turn it off at night and on weekends.

While the energy-saving suggestions listed above are appropriate for many campus PC users, some of the suggestions may be inappropriate for certain computer applications or work situations. When in doubt, discuss possible energy conservation measures with your colleagues, supervisor, or computer lab director to determine which steps can be taken without harming productivity. Our energy conservation program will not work without your help. Be an energy educator and gently remind your co-workers and colleagues to save energy by changing their computer habits.

4. The Significance of Virtualization and Cloud Computing in Green IT

The most-significant step most organizations can make in moving to green data centers is to implement virtualization for their Information Technology (IT) data center devices. The IT devices include servers, data storage, and clients (or desktops) used to support the data center. There is also a virtual IT world of the future - via private cloud computing – for most of our data centers. Although the use of cloud computing in your company's data center for mainstream computing may be off in the future, some steps towards private cloud computing for mainstream computing within your company are currently available. Server clusters are here now and being used in many company data centers. Although cost reduction usually drives the path to virtualization, often the most important reason to use virtualization is IT flexibility. The cost and energy savings due to consolidating hardware and software are very significant benefits and nicely complement the flexibility benefits. The use of virtualization technologies is usually the first and most important step we can take in creating energy efficient and green data centers.

A. Reasons for Creating Virtual Servers

Consider this basic scenario. You're in charge of procuring additional server capacity at your company's data center. You have two identical servers, each running different Windows applications for your company. The first server – let's call it Server A – is lightly used, reaching a peak of only 5% of its CPU capacity and using only 5% of its internal hard disk. The second server – let's call it Server B – is using all of its CPU (averaging 95% CPU utilization) and has basically run out of hard disk capacity (i.e. the hard disk is 95% full). So you have a real problem with Server B. However, if you consider Server A and Server B together, on average the combined servers are using only 50% of their CPU capacity and 50% of their hard disk capacity. If the two servers were actually virtual servers on a large physical server, the problem would be immediately solved since each server could be quickly allocated the resource each needs. In newer virtual server technologies - e.g. Unix Logical Partitions (LPARS) with micro-partitioning – each virtual server can dynamically (instantaneously) increase the number of CPUs available by utilizing the CPUs currently not in use by other virtual servers on the large physical machine. This idea is that each virtual server gets the resource required based on the virtual server's immediate need.

My favorite diagram for describing the reasons to use server and data storage virtualization is shown in Figure 2.

This diagram shows typical server utilization for stand-alone servers (i.e. NO virtualization). The multi-million dollar mainframes are typically utilized on a 24/7 basis at least partly because of the large financial investment. Mainframe "batch" processes such as running daily, weekly, and

monthly corporate summary reports are typically CPU intensive and are run at night and on the weekends. The small department Windows server (labeled "Intel-based" in the diagram) is not typically used at night or on the weekends. Creating virtual servers of those Intel-based servers not only allows much better and easier sharing of resources for a mix of lightly and heavily used servers (as in the Server A/Server B example above) but also tends to spread out the utilization over 24 hours on the large physical server that houses the virtual servers.

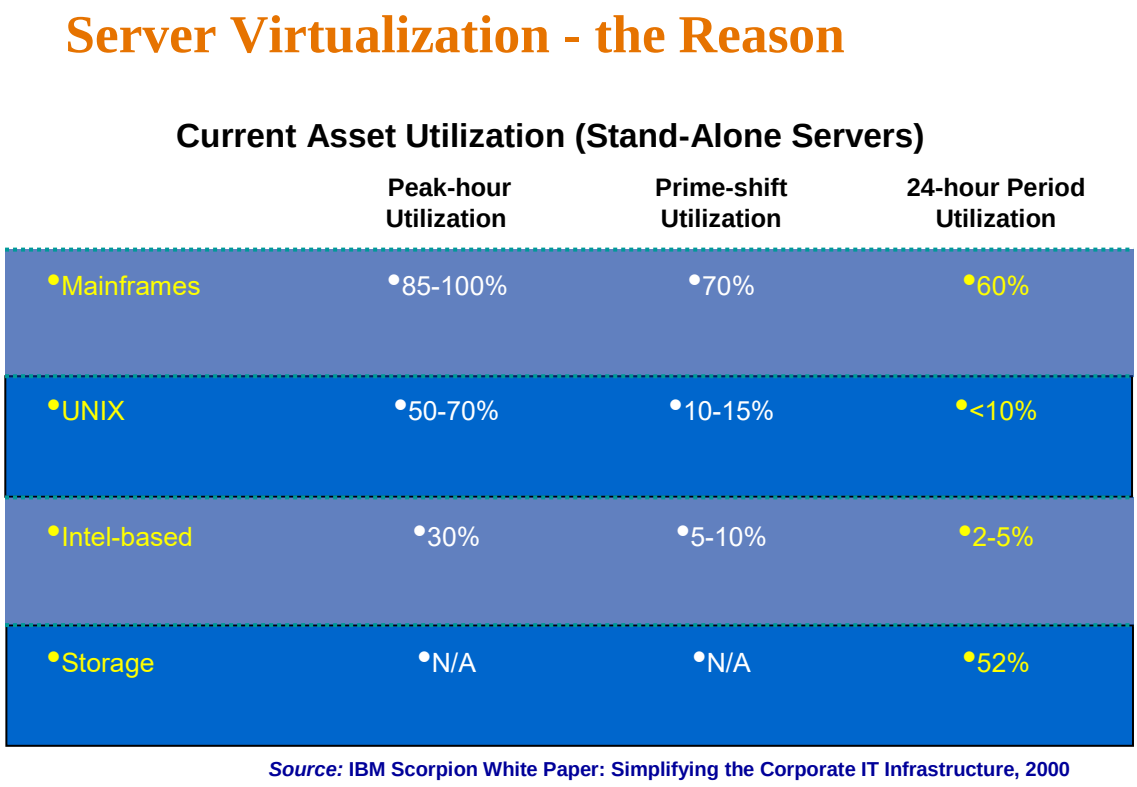

Figure 2. Server Virtualization – the Reason

5. STEAM, STEM, Healthcare, and Green IT

Much of the information in this section relating to hospitals and healthcare, in general, comes from my collaboration with Nina Godbole, who is a PhD student at UPES (University of Petroleum & Energy Studies), in Dehradun, India. Nina works for IBM India and she asked me to me an official mentor for her PhD work on "Green IT and Hospitals" [6, 7]

Globally, the healthcare sector [8] is growing in importance and plays a key role in our economy. The healthcare sector makes heavy use of technology including social media. Technological advances have brought about a revolution in the healthcare industry worldwide – from modern testing techniques to improved surgical equipment, remote health monitoring technologies with the help of modern digital equipment, etc. [7]. There are many online healthcare portals. The complexity of the healthcare industry helps account for the large environmental footprint. Healthcare accounts for 8% of the U.S. carbon footprint [9, 10, 11, 12, 13].

Healthcare should be an area of significant interest to both STEM and STEaM students worldwide. Green IT is a financially rewarding way to promote green healthcare.

6. Ways to Promote STEM and STEAM Green Initiatives

"If You Can't Measure It, You Can't Manage It" (Quote attributed to many, including W. E. Deming and Peter Drucker). In order to measure green IT, we must have standards as to what constitutes green IT. The standards are IT energy-use metrics. Promoting green initiatives is part of the social responsibility aspect of solving the climate crisis and should be of great interest to both STEM and STEaM students. Students in the arts could use their artistic skills to design and promote green initiatives and that would nicely complement the technical skills of their STEM colleagues.

In addition to measurements for IT energy use, there are also the measurements for green buildings, such as the Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC). LEED provides a suite of standards for environmentally sustainable construction. LEED does not relate directly to green data centers, but rather to the overall building.

Another metric for green IT is EPEAT, the Electronic Product Environmental Assessment Tool. EPEAT was created through an Institute of Electrical and Electronics Engineers (IEEE) council because companies and government agencies wanted to put green criteria in IT requests for proposals. EPEAT got a big boost in January 2007 when President Bush signed an executive order requiring that 95% of electronic products procured by federal agencies meet EPEAT standards, as long there's a standard for that product. First, however, we'll look at some standards and metrics specifically developed for measuring IT and data center energy efficiency, such as SPEC marks and the metrics being developed by the EPA. The EPA is pushing for metrics for all aspects of data center use and the EPA metrics should be the guideline for green data centers.

The Standard Performance Evaluation Corp. (SPEC) benchmark information has been used for years to compare servers from a power aspect. In the author's experience, companies are very interested in SPEC marks when comparing new servers. Customers use the SPEC marks in order to compare relative power. Here's the SPEC homepage: http://www.spec.org/

In 2008 SPEC started a benchmark to compare the power consumed by a server with its performance - a metric designed to aid users in boosting data center efficiency.

A. Energy-Use Dashboards at Montpelier, France

The demo data center in Montpelier, France is called the PSSC (Products and Solutions Support Center) Green Data Center of the Future [1]. The main idea was to create a customer friendly real-time green showcase production data center that will demonstrate a large percentage of the currently available best practices in IT and facilities energy conservation, integrating at least one bleeding-edge major conservation technology. The information on the use of a live camera, thermal camera, and green IT energy use real-time dashboards available to IT personnel through a portal are interesting innovations that can help communicate the energy efficiency of the data center to all interested employees.

The Power Usage Effectiveness (PUE) is the metric used to measure the energy efficiency of a data center. Both IT and non-IT resources' energy consumption are gathered. Two PUEs are measured: overall and high-density zone.

For demo purposes you can show in real time the PUE of the PSSC Green Data Center. Although the PSSC green data center is for demo purposes, these energy use dashboards would be useful for any data center to raise company awareness on IT energy efficiency. These dashboards remind me of the real time gas mileage graphics on the Toyota Prius automobile I recently rented. The graphics on

the Prius' dashboard constantly reminded me that I was getting around 42 miles per gallon and informed me when the car was using the electric motor and when it was using the gas engine (and charging the battery). The data center energy use dashboard for the Montpelier demo center is shown in Figure 3.

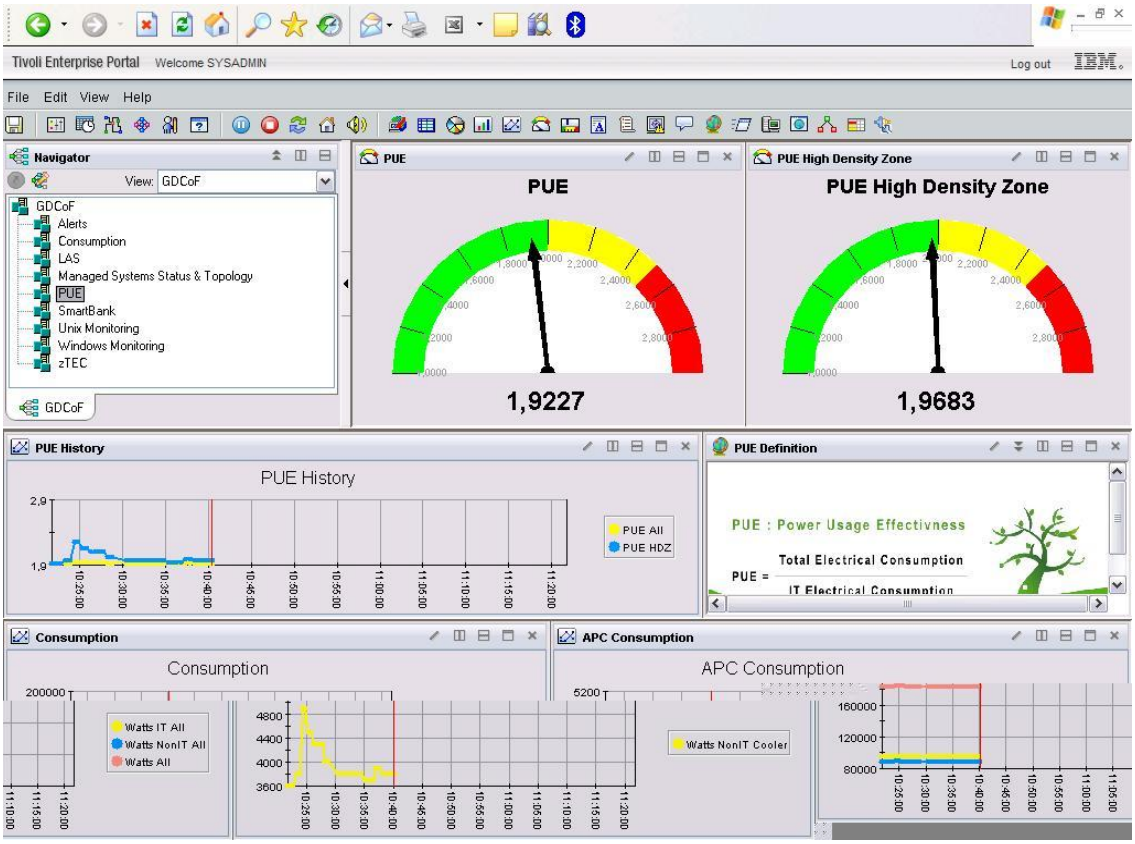

Figure 3. Montpelier PSSC Green Data Center Energy Use Dashboard
(Source: IBM Montpelier PSSC Green Data Center Team)

B. Smartbank – Smart Green Infrastructure Monitoring at the Solution Level

Monitoring at the PSSC can be done at the Solution Level. Smartbank is a "live" showcase involving many platforms. For demo purpose, the monitoring of an entire solution can be demonstrated. Active Energy Manager is implemented for the energy management of z10 and Blades. The Smartbank solution level monitoring is shown in Figure 4. As stated for the previous dashboard, these data center energy dashboards can communicate current energy efficiency to interested IT team members just as the hybrid automobiles constantly remind the driver with dashboard gas mileage graphics. The real-time dashboard can give the IT team immediate feedback on how data center energy management techniques impact data center energy use just as the hybrid automobile gas mileage dashboard gave me immediate feedback on how my driving technique impacted automobile energy use.

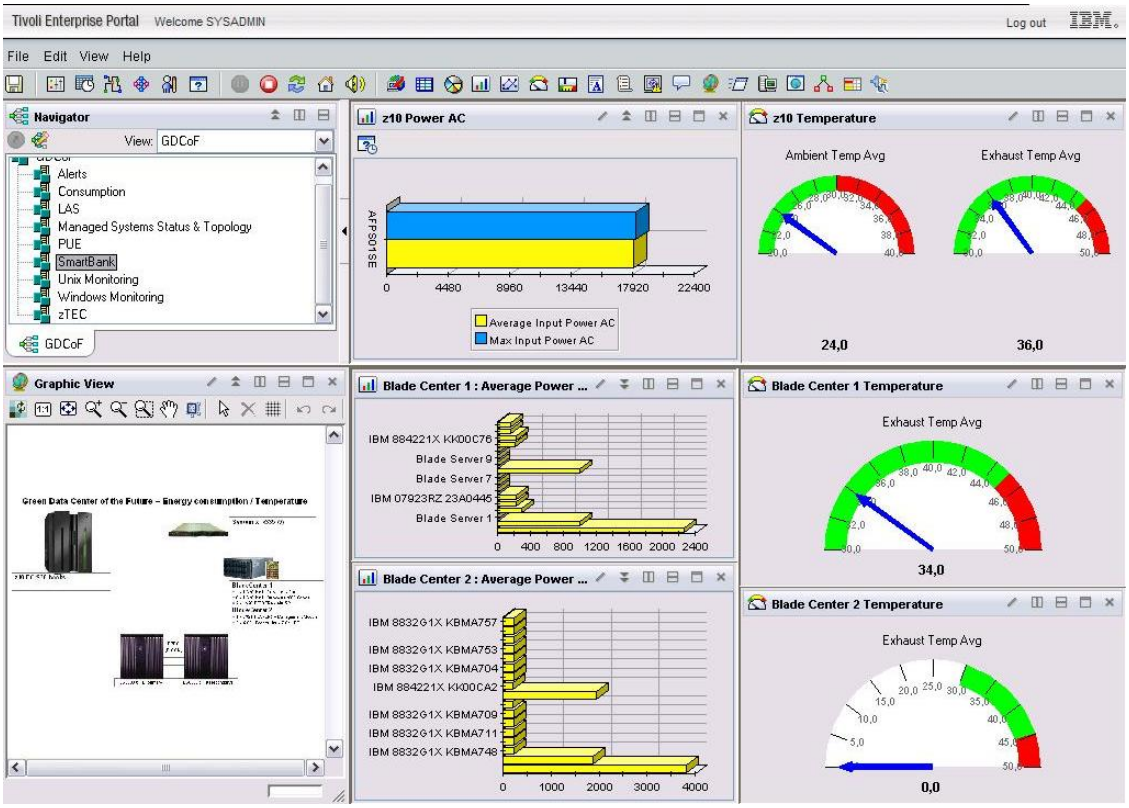

Figure 4. Montpelier Green Data Center Smartbank - Solution Level Monitoring (Source: IBM Montpelier PSSC Green Data Center Team)

Innovation at the PSSC data center is summarized in the following list.

- Web Camera showing the implemented technologies.
- A solution to track people and assets.
- Dynamic and graphic visualization of the temperature, pressure and humidity in the Green Data Center.
- A thermal camera to visualize hot spots at the server and rack room levels.
- TEPS (Tivoli Enterprise Portal Server) workplaces are used in order to show the monitoring and management of IT and non-IT resources.

Now, we'll look at the significant advantages of new technologies for improving green IT.

7. New Technology for Green IT

This section describes some of the emerging technologies that could significantly improve green IT at any organization.

A. Fuel Cells for Data Center Electricity

Fuel cells have been proposed to power data centers. For instance, the polluting diesel back-up generators that most data centers rely on may be replaced by fuel cells. In 2008 Fujitsu began using a fuel-cell generator to power its data center in Silicon Valley. Fuel cells have also been proposed to be used in an emergency or during peak demand to take some of the load off the grid. Hydrogen powered fuel cells are very environmentally desirable since the only output, in addition to energy, is water. The problem is in obtaining the hydrogen. Currently hydrogen is usually produced through a very energy intensive process using natural gas and immense amounts of electricity. When technological breakthroughs allow us to produce hydrogen efficiently, then fuel cells for data center energy will be a significant step forward.

B. Other Emerging Technologies for Data Centers

Energy costs will likely continue to rise in the future as will the computing requirements of most organizations. Taking steps today to increase the efficiency of the cooling system can offset the impact of rising energy costs when newer, higher-efficiency technologies are deployed. Four technologies, in particular, have potential to significantly enhance data center energy efficiency:

- Multi-core processors
- Embedded cooling
- Chip-level cooling
- SSD (Solid State Device) storage technology

Newer servers are now based on multi-core processors that enable a single processor to perform multiple separate tasks simultaneously, run multiple applications on a single processor, or complete more tasks in a shorter amount of time. Chip manufacturers claim that multi-core processors can reduce power and heat by up to 40 percent [4].

Embedded cooling uses the cooling infrastructure to deliver high-efficiency cooling directly inside the rack. This approach brings cooling even closer to the source of heat and allows the cooling system to be optimized for a particular rack environment. This type of system is able to prevent heat from the system from entering the room by removing the heat before it leaves the rack.

Chip-level cooling takes this approach to the next level by helping to move heat away from the chip. As embedded and chip-level cooling solutions are deployed, a highly efficient three-tiered approach to data center cooling will emerge. In this approach, heat is effectively moved away from the chip and then cooled in the rack, with stable temperatures and humidity maintained by room air conditioners. These developments are not expected to reduce data center cooling requirements. Instead, they will result in an increase in the amount of computing power that can be supported by a particular facility. As a result, the efficiency improvements made today will continue to pay dividends well into the future as these new developments enable existing facilities to support densities that are not possible today.

The cooling system represents a significant opportunity to improve efficiency. In many cases, relatively simple and inexpensive changes - such as improving room sealing, moving cables or other objects that obstruct airflow or installing blanking panels - can pay immediate dividends. In addition, new technologies, such as variable capacity room air conditioners and sophisticated control systems, should be considered for their impact on efficiency. Finally, supplemental cooling systems provide a response to increased equipment densities that can increase the scalability and efficiency of existing cooling systems.

SSD (Solid State Device) storage technology can significantly reduce energy needed for storage and significantly increase storage access speed. SSD is the same technology used in our flash drives, but for data centers SSD is used to replace terabytes of spinning disk technology. In the author's experience, SSD can greatly improve the speed for large database applications since data access is immediate due to random access and the database program doesn't experience the delays incurred waiting for the spinning disk to reach the start of the data needed. As we know from the use of our flash drives, SSD technology requires very little power and creates very little cooling. The cost of SSD continues to come down and we can expect spinning disk technology to continue to be replaced by SSD. That's great news for energy efficiency at data centers.

8. Conclusions

Green IT is an excellent STEM and STEaM topic. It will incite interest in all students, those interested in both technical areas and the arts, since it involves the tools all students use (PCs, laptops, IPads, smart phones and all the social media used by those devices). The most recent UN Climate agreement on reducing carbon emissions reached in Paris during December, 2015, will continue to raise awareness to the need to reduce electricity use through efficiency. Green IT is an excellent way to reduce electricity use and save money doing it. Al Gore's excellent book "Our Choice: A Plan to Solve the Climate Crisis" [16], and many other publications continue to point to the urgency of having everyone worldwide help to solve this urgent crisis. Green IT is an excellent way for both STEM and STEaM students to contribute.

As discussed in this paper, Green IT includes all of the components of STEM, i.e. Science, Technology, Engineering and Mathematics. The arts, especially design, make Green IT very applicable to STEaM projects. The future of green IT is being shaped now - based on university, corporate, and government research, regulations, incentives, etc. Based on the dynamic aspect of IT, we have already made significant progress with green computing and can build on that past.

One of the most important arenas for development of green IT is that we must have better measurements in order to better manage energy use at data centers and throughout the corporation. We will see great strides here, for example, like gas mileage monitoring on the Honda Prius hybrid. Currently we can use data network "sniffer" concept to determine network bandwidth and response time for each user of a server. That same sniffer concept will be developed for power and energy used. There will be an inexpensive power/energy monitoring appliance that will act like the network sniffer and give us information on the power and energy use for each IT device. That appliance will send the information to an energy monitoring system (a server). Then we can see actual energy reduction results of using virtualization and other energy saving initiatives. The electric power/energy monitoring device will also be in our homes and will have the capability of sending information to our laptops. Then we'll be able to see the actual power and energy-use history of our refrigerators or window air conditioners. We then will be able to better manage our energy use by measurements and trending.

Going forward, we in IT all have a role in helping improve the outlook for Green IT by contributing to IT infrastructure electric energy sustainability, and the continued improvement in cloud computing for IT cost reduction along with improved data protection.

Acknowledgments

The author acknowledges the significant contributions from Andra Meyerson of the Yorktown Heights, New York school districts and her STEM teachers who contributed to this paper through discussions about their student projects. The author also acknowledges the significant contributions from Phil Poggiali of the Pace University Library who helped with research using the Pace library tools. Also, much of the information in this paper relating to hospitals and, in general, healthcare, comes from my collaboration with Nina Godbole, who is a PhD student at UPES (University of Petroleum & Energy Studies), in Dehradun, India. Nina works for IBM India and she asked me to me an official mentor for her PhD work on "Green IT and Hospitals".

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SUSTAINABLE DEVELOPMENT CONFERENCE
7-9 JULY 2016
KUCHING, MALAYSIA
CONFERENCE PROCEEDINGS

ISBN 978-86-87043-40-4
