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Research on Ethnic Eco-ethics and Eco-civilization's Construction in Chinese Ethnic Regions

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Abstract

Eco-civilization is the integral product of material achievement, spiritual achievement and regulations. It's the cultural & ethical manifestation of the harmonic coexistence of humans & nature, balanced development, sustainable prosperity. The key ideology is the harmony and equality between nature and humans, the co-existence of multi-species and the re-production of resources. The nature ideology of integral harmony of the Chinese minority nations, and their ideology of equality of admiring life and the ideology of production of simple circulation are identical to the central ideology of eco-civilization. It reflects mankind's pursuit for a natural and harmonious ecology. And it plays a positive role in the construction of ecological civilization. To some extent the ecological ethics of the minorities is very important to protect the natural ecological environment, and promote the continuous and harmonic development of the ethnic regions. In this paper the method to construct the eco-civilization in Chinese ethnic regions are explained, such as the development of the eco-ethics of the minorities, and educate the sense of eco-citizen, perfection of the policies and regulations to protect the ecological environment of the ethnic regions.

Keywords: Ecological ethics, Ethnic regions, Eco-civilization, Circular economy

1. Ecological civilization and the ecological situation in the ethnic regions

Since the beginning of last century, industrial civilization brought a lot of issue as well as progress made in technology & material wealth. To a certain point, these issues are anti-human & anti-nature. The environment is only treated as resources, carrier & receptor. The model of over consumption, high pollution caused the depletion of resources, pollution of the environment & the deterioration of ecology. While enjoying economical prosperity, mankind sacrifices hygiene, health, pleasant environmental conditions, & peace of mind. People have to rethink about the consequences and try to find a new model of development for the sake of sustainable development for future generations. Science then mankind entered eco-civilization period. Eco-civilization coordinates social-economical development with the environment & natural resources, establishes a new civilization based upon mutual benefit & coordination between man & nature. It's a cultural & ethical manifestation of harmonious coexistence, well-rounded development, and sustainable prosperity between human & nature.

Eco-civilization has the following aspects: the first is the harmony and equality between man & nature. Eco-civilization requires the culture value view-point of eco-system, humans regard nature protection as their inherent faith rather than humans-oriented. The second is production under the precondition of sustainable development. Obeying the principle that the ecological system is limited, elastic and unable to be predicted completely, the work of us, humans has to use natural resources in a way that's economical, synthetic and recyclable. An ecological industry system needs to be formed which becomes the main source of economical development. The third is consumption to satisfy one's own need without harming the environment. The life style of "living by no more than essential demand" is recommended, by which the pursuit of mankind is not materialism but to satisfy one's own need without damaging nature, to satisfy the need of this generation without harming the prospects of future generations. This ethics of peace and sharing is the code of harmonic coexistence and development between humans and nature, and within human society.

In our country, the habitats of the minorities are mostly located in the aboriginal and mountainous areas. From the

northeast, northwest and southwest border areas make up most of the autonomy of minorities. Many of these places are; deserts, woodland and mountainous areas where the natural conditions are poor. Due to the historical, geological and social reasons, the ecological environment issue is especially remarkable, which becomes the key factor to restrain the development of the ethnic regions. The four major ecological fragile belts of our country (severe cold, deserts, infertile yellow soil and Karst) are the main distribution in the areas of minorities. In the process of industrialization, the ecological environment of minority areas tends to deteriorate severely with series of severe ecological crises, such as the over-use and destruction of the forests and wetlands, the deterioration of woodland, the lost of water and soil, drought and water shortage, flooding, desertification, extinction of native plant and animal species etc. (e.g. Table 1 as follows) Certain places fall into the malignant cycle of "poverty-destruction-poverty", which not only affects the existence and development of the people in the minority areas, but also generate environmental refugees and collision between races, affects the stability of the minority areas and the safety of the boundaries, which may also turns in to corresponding social risks.

The ethnic areas (five auto-autonomy regions and three provinces Yunnan, Guizhou and Qinghai etc. with more minority populations) are the boundary's green shield of the motherland, the treasure house of multi-ecological status with rich ecological ethics and culture, also have advantages of natural resources, the advantage of multi-ecological status, the advantage of culture and the organizational advantage of autonomy of the ethnic regions. Whether if the production is developed, the richness of life and the well development of ecology, the harmonious development of the economy with minority characteristics and the construction of ecological civilization is an important subject related to whether the idea of scientific development can be materialized in our country and to reach the goal to construct harmonious society.

2. The conformability between the eco-ethics of ethnic minorities and the core value of the eco-civilization

During the long-term process of interacting with nature ethnic minorities established their unique way of survival & cultural ethics, formed their unique national customs and eco-ethics of protecting environment and wild animals.

2.1 The nature view of overall harmony

To treat nature with respect is the kind of harmonic model of handling the relationship between man and nature by ethnic minorities. It takes man & nature as an inseparable entirety, maintains that nature is the basis of human life and eternal destiny, and that human & nature must rely on each other, coexist in prosperity and develop in coordination. For example, people who are in belief of Shamanism in north China believe that humans should treat nature and all creatures with respect, live in harmony with all kinds of different organisms. This ecological idea no doubt regulates the behavior of ethnic minorities & promotes environmental protection of nature and ecological harmony.

2.2 The view of renewable production

Since it's very hard to choose their ecological environment, ethnic minorities have to conduct production activities under realistic natural conditions, and their views on everyday living are evolved to adapt distinctively to the unique geographical environment. The existence of these concepts plays an important guidance role in waste reduction, green consumption, less impact on nature and wild animal protection. It also maintains local ecological balance, coordinates the harmonic fusion between man & nature, and promotes practical natural way of living which restores nature to its original condition. For example, the nomadic way of constant migration for animal husbandry, and the nomadic way of rotation of grassland and pasture to reduce pressure on human activity, to ensure that pastures and water sources inexhaustible, not only to promote the benign cycle of grassland ecosystems, but also the protection of sustainable development of animal husbandry; Hani, Dai, Dong etc. rice-growing and other ethnic groups in south China developed the concept of forest ecosystems, which provides sufficient water and a friendly ecological environment for rice production under the *forest-water-farm* land model.

2.3 The view of equality from revering life

Due to the limitation of productivity level, ethnic minorities usually deify nature & natural creatures. Worship for heaven & earth is the most important content of worship of nature. Tibetans' ancient ideas believe that all species are from the same origin and lives are correlated; Uygurs view their existence as sustained by the Eternal Blue Sky, Tengri, the fertile Mother-Earth Spirit Eje, and a ruler who is regarded as the Holy Spirit of the Sky. Heaven, earth, the spirits of nature and the ancestors provide every need and protect all humans; Dai and Bulang in Xishuangbanna of Yunnan province both have the fine tradition of worship and protection of the "Dragon Mountain"; The Yi minority deify the trees around the village, while the Qiang and Bulang treat the forest as a god; The Dai believe that the elephants and the peacocks are auspicious things, people will not allow any harm to them; The Tokenism from North Shamanism regard bears, wolves, eagles etc. as their gods. All of these contribute to the protection of the ecological resources of mankind in an important way. Especially in animal protection, ethnic minorities have developed the ethical awareness of wild life conservation.

Civilization thrives while ecology does, and Civilization withers with ecology. The core value of the eco-culture is that

man should live in harmony & equality with nature, and all species should co-exist with renewable resources, which is fundamentally in consistency with the ecological ideologies of ethnic minorities. Man and other species are not divided into high and low social status, we are in one natural system, which is consistent with minorities' concept of "equality in awe of life". Different species in nature are bond to each other & are dependent on each other, and they maintain balance and stability of the earth eco-systems. Distinction should not happen by over-development of other species, which reflects ecological ethics "the overall harmony of the natural". Nature evolved from inorganic to organic life and developed a natural cycle of regeneration of the eco-system from energy to the material, the view of "simple cycle of production" of ethnic minorities will help to maintain this cycle of regeneration.

Ecological crisis is the greatest of mankind's survival, and the crisis was mainly due to human misconduct when people's ethical culture has erred. Therefore, the ecological crisis is essentially an ethical crisis of faith and it is a cultural crisis. The history and social development of ethnic minorities is in fact the history of the relationship between ethnic minorities and the natural environment. Ethic minorities bound by their culture, norms, have constantly adjusted their behavior and the relationship between man and nature, protected the natural ecological environment, maintained national cohesion, and promoted harmonic sustainable development in the regions of ethnic minorities.

3. Research on ecological civilization construction strategies in ethnic areas

The basic contradiction of the eco-economic system is that of a growth-oriented economic system of unlimited demand for natural resources between ecosystems with limited stable supply of natural resources. On the one hand, the development demand of human activities on ecosystems are increasing; on the other hand, the supply of the overloaded ecosystem continues to decline, especially for the more vulnerable ethnic minorities' ecological areas, where economic development, social progress and ecological civilization face various pressures and challenges. In order to comprehensively building a harmonious society and sustainable economy and social development, ethnic minority areas should promote the construction of ecological civilization from multiple aspects.

3.1 Inherit and promote eco-ethics from ethnic regions

The rational factor in China's traditional eco- ethics in minorities is an intuitive and simple sentimental concept, without a comprehensive exposition on the relationship between man and nature. The integration of ecological ethics of minorities and the modern ethics is a rational choice for the reservation of ecology and the harmonious development in ethnic regions. The shared prosperity and a harmonious society of ecological civilization have to be ultimately achieved based upon the ecological ethics from minorities through the absorption of the theory of modern science to fit their specific situations. With the development of society, ethnic minorities have been unable to adapt to ecological ethics in pursuit of a modern society for the purpose of maximizing the economic benefits of large-scale material production activities. Therefore, the inheritance of traditional eco-ethics from minorities must be uplifted so that it is built on the basis of modern science.

3.2 The cultivation of "ecological citizenship" awareness

Ecological and environmental problems are essentially human survival and development issues and ecological civilization construction calls for "eco-citizenship." Through the promulgation of the ecological environment education, the whole nation's ecological awareness will be enhanced; the code of conduct in protection of the ecological environment will be established; and the concept of gradually establish a view of coordination of nature, a moderate and reasonable consumption and the sustainable development will be brought to light. "Civic awareness" is better over 1000 laws and regulations and the cultivation of "eco-citizens" is an essential requirement for the sound development of the ecological environment. The development of "sense of eco-citizens" is responsible for the "civic responsibility" in solving ecological problems in a fundamental way. Though fully understanding the rational factors in decision-making behavior of individual citizens and through legal, administrative, economic and other incentive-based measures, supplemented by a means of enforcement, combined with eco-ethics from ethnic minorities, an established code of conduct conscious citizens is the most effective, ever-lasting and prevention-over-restoration approach for ecological conservation.

3.3 Improve related policies and regulations related to protect the ecology of the ethnic regions

Rich ecological ethics are included in the life and production of ancient Mongolian, which leads to the prosperity of the Mongolian grassland in hundreds and thousands years. Basically the Mongolian grassland kept its primitive natural status until the middle 18th century. As early as the dynasty of Genghis Khan, the destruction of ecological environment is listed as national prohibition, e.g. The hunting of immature animals are prohibited, trees were not allowed to be cut indiscriminately. "Those, who destroy the farming-land, will be punished … the whole family will be executed if one forgot to extinguish fire and burn the grass land" was also a law at that time.

The system of ecology compensation funds should be improved in the minority areas, which makes the ecological compensation vertically from the government more specific and reasonable (The subject and object of the compensation, the standard and type of the compensation etc.). Especially the minority areas may fully take advantage of the "the law

of autonomy of the ethnic regions" and the advantage of privilege of setting new laws of the government (especially the privilege of making changes accordingly). The national laws and regulations may be detailed, specific regulations may be added for execution to increase the operability and vigorously protect the construction of ecological civilization and the continuous development of economy and society. For example, in 2008, more than 1 million Yuan was provided through the regional & county level finance of Ali to compensate the losses of the local people by wild animals. This is another example of "pay the bill" by government since the adoption of "Tibet Autonomous Region, Provisional Measures for Property Loss & Personal Injuries by Prominent land Wildlife" by the government of the Tibet Autonomous Region in 2006.

3.4 Developing the unique economy in circular model

The value of the agriculture and industry is an economic value centered on the human being, while the ecological civilization requires to form an ecological value based upon the harmony of human and nature. The activities of human beings should be constrained within the limits of the natural ecological system, i.e. the economical construction and the ecological civilization should develop in harmony, obey the inner rule of the composite system of "society-ecology-economy".

The more national it is, the more international it is. With the development of economy and the society, people change from the consumption for existence to culture and unique consumption. To have advantages in the competition of the marketing economy, the minority areas must develop unique economy, cultivate and develop unique industry which reflects the nationality, the region and the ecology. The unique industry of the minority areas has broad commercial potential, e.g. The tobacco of Yunnan, the Gouqi of Ningxia, the oxen wool of Tibet, the raw paint in the west of Yunnan etc. Especially with the popularity of modern tourism to pursue uniqueness, knowledge and difference, the unique minority tourism has become the main industry in the regions of Yunnan, Tibet and Qinghai. The minority areas should combine local national characteristics – national situation, regional advantages – regional situation, market need – commercial situation, to choose developing characteristic industry, explore how to use advanced techniques and skills to convert the potential advantages to real economical advantages and to realize the jump of the economy, choose the characteristic industry and those which may be able to co-existent, explore the model of unique circular economy development.

References

Baoli Bai. (2007). A study on the ecological ethics of the Chinese minorities (D), Beijing: Dissertation of the Central University of the Minorities, 3.

Hellstrand, S. (2006). A multi-criteria analysis of sustainability effects of increasing concentrate intensity in Swedish milk production 1989-1999. Environment, Development and Sustainability, 8(3), 351-373.

Jiancheng Chen. (2008). A study on the ecological civilization and the continuous development of the Chinese forest industry, Chinese hunan resources and the environment, 4, 139-142.

Kay, J. J. (1991). A nonequilibrium thermodynamic framework for discussing ecosystem integrity. Environmental Management, 15, 483-495.

Kfiberger, T., & Mfinsson, B. (2001). Entropy and economic processes--Physics perspectives Economics, 36, 165-179.

Landner, L., Hellstrand, S., & Mikaelsson, H. (2000a). Cadmium in phosphate fertilisers: Consequences of an eventual European standard limit. Stockholm: AF-Environmental Research Group Ltd. (AF-MFG).

Ming Jiang, Liqing Hou. (2008). The ecological culture of the woodland and the construction of the ecological utility area of Neimenggu, Ecological environment and protection, 1, 54-58.

OECD. (2001). Policies to enhance sustainable development. Meeting of the OECD Council at Ministerial level, 2001. Accessed March 29, 2008 from http://www.oecd.org/dataoecd/47/22/1869800.pdf.

Yi Zeng. (2008). The harmonic value of the minority ethics, The learning journal of the Guizhou Institute of Minorities (The version of philosophy and social study), 2, 73-76.

Table 1. The status of ecological environment of ethnic regions

Ethnic region	Ecological environment issues	Human factors	Natural factors
Neimenggu	Regression of woodland, desert of field, lost of water and soil, industry pollution	Overgrazing, extensive management	drought
Xinjiang	Desert of field, salt and alkaline of field, lost of soil and water, shortage of resources, industry pollution	Over grazing, indiscriminate logging, over reclamation, extensive mining	Drought, desert area
Ningxia	Sand of field, salt and alkaline of field, shortage of water resources, industry pollution	Overgrazing, extensive management	Drought in north area, complicated terrain in south
Qinghai	Sand of field, shortage of water resources, lost of water and soil, shrink of woodland and forest, decrease of multi-biology	Overgrazing, indiscriminate mining, extensive management	Alpine weather, fragile ecological system
Guangxi	Rock of field, decrease of multi-biology, lost of water and soil, shrink of wetland and forest, industry pollution	Over logging, farming on marine reclamation land, extensive mining	Fragmented terrain, Karst areas
Tibet	Regression of woodland, desert of field, lost of water and soil, decrease of multi-biology, decrease of coverage of plants	Indiscriminate development on wet land, indiscriminate mining/logging/hunting	Cold-arid climate, fragile ecology, prone to natural disasters
Guizhou	Rock of field, lost of water and soil, shrinkage of the forest, severe environmental pollution, frequent natural disasters	Land reclamation through deforestation, cultivation on steep, indiscriminate mining, extensive management	Fragmented terrain, Karst areas, prone to natural disasters
Yunnan	The lost of water and soil, rock of the field, the shrinkage of the forest, frequent disasters, industry pollution, worse of the water quality	Over logging, extensive management	Karst areas, prone to natural disasters

References: Wang Zhonghua (2005). Research on Economy Development and Ecology Protection in Ethnic Areas, 89.

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Value –Based Maintenance Management Model for University Buildings in Malaysia-A Critical Review

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Abstract
The essence of building maintenance is to increase the service life of a building by delaying deterioration, decay and failure. Building maintenance must therefore be considered as a strategic process if the value of a building is to be sustained. Building maintenance management is a complex and multi-faceted thought process that involves planning, directing, controlling and organizing maintenance services for the sustenance of the value of a building. It entails making intricate decisions under complex algorithms, uncertainty and risks within organizational resources. The purpose of this paper is to propose an alternative maintenance management model for university buildings in Malaysia. The proposed model reflects current thinking on building maintenance management. A number of studies have investigated the maintenance management of university buildings in Malaysia; however, all the studies have observed maintenance management procedures that are corrective and condition based. Nonetheless, this is contributing to the spate of maintenance backlogs and the lack of value delivery to the stakeholders. Although the research specifically focused on university buildings, many public and private sector organizations face similar maintenance management problems. Therefore this research has broader applications. The outcome of this research is to come up with a prototype maintenance management model that can facilitate university institutions to carry out buildings maintenance management services that meet the expectations and perceptions of the stakeholders.

Keywords: Maintenance management, University buildings, Malaysia, Value, Users

1. Introduction

This paper is part of an ongoing research project on building maintenance management. The overall aim of the research of which this paper forms part of is to develop a building maintenance management that is based on the concept of value. A building requires maintenance to ensure its optimal performance over its life cycle. The value of a building from the user's perspective can be viewed as the measure of how efficiently and effectively a building meets the users' needs with the available resources. However, there is no conclusive literature on how well university buildings are maintained in Malaysia. However, it is contended that university buildings like other public buildings in Malaysia are not well maintained. This is based on the premises that across the whole spectrum, similar or the same maintenance management systems are applied to public buildings in Malaysia even though previous studies have found that the maintenance management systems for the university buildings are not cost-effective. In part, a salient point in this research is to incorporate value criteria and concepts within the process of maintenance management of university buildings. The premise is very much that the focus of maintenance should be driven by the building users. The focus of most public organizations on building maintenance has been usually corrective or preventive and is mainly based on the condition of the buildings as revealed through inspection. According to this, the condition of the building is revealed through a condition survey without recourse to the stakeholders' perceptions and expectations. However, the only reason for providing buildings is to enable them to be used by their occupants. It is not the condition of the building that really matters but the functions which the building is performing. It is therefore, the needs of the buildings users that should dictate the maintenance management processes in terms of policy, purposes and objectives. As a result, it is pertinent for those reasons to consider maintenance management as a value added initiative that seeks to be addressing user needs. Such a consideration is entirely consistent with the principle and philosophy of value management. Value is the relationship between functional performance and the resource used to provide the function (Figure 1). Value is used in this research to define the user's / owner-occupiers satisfactions with the quality of the maintenance service provided and the resource used. Value based maintenance management puts the user's value system at the centre of initiating maintenance service. A university cannot fail to meet the requirements of its clients (users). In fact, these days' universities usually promote the design and performance of their buildings to woo students. The paper is structured as

follow; it commences in section 1"theoretical framework" with the background on the maintenance management procedures. In the last section, "Synopsis and Further Research" the conclusion of the paper are provided and continue to provide information on the fundamental weaknesses in the maintenance management procedures which are noted to be factors leading to building maintenance backlog and poor service delivery.

2. Theoretical Framework

Buildings are designed to address some technical problems as identified by the clients / users (Kelly and Mala, 2001. For instance, some buildings are required to solve space requirement problem. Buildings, generally once they have been completed are expected to perform certain function for a certain period. However, a building must be maintained to keep it in optimal operation. Building maintenance is inevitable as the need for maintenance will only intensify as the value of the building must be preserved for it to be meaningful to its users (and owners) since:

> *"Even before a building is completed, Nature begins to destroy it systematically, and gravity, wind and seismic movement constantly test the stability of the structure. The ultraviolet wavelengths of sunlight fade and decompose organic building materials through molecular breakdown'' (Allen, 1995 and 2005).*

Accordingly, birth, growth, maturity, decline, decay, death, and rebirth are fundamental stages in all natural cycles and so too with buildings, although humans like to keep the cycle under control through maintenance until its death suits human purposes (Allen, 1995 and 2005). It is not only nature that destroys buildings; buildings are also destroyed by human activities. Buildings may not perform satisfactorily as a result of inadequate design, poor workmanship, defective materials and components, wrong installations and applications and the failure to provide the required maintenance. However, assuming the initial design was adequate for the intended use, the quality of workmanship was high, the materials and components selected were of high quality and installed properly, any inconsistencies from the predicted service life can be attributed to maintenance (Kalinger, 1997). According to Scrhrag, Smith and Stollenwerk (2007), new buildings are often beautiful, meet the required energy standards and are functional for the occupants are state-of-the--art and stakeholders are happy, but behind the scenes are the maintenance requirements of the buildings. Maintenance, therefore, is essentially required to delay decay, defects, deterioration and failure to ensure that buildings perform optimally throughout their life cycle so that they represent value to the various stakeholders' and, notably, the users.

Maintenance means different thing to different people. However, in this research, maintenance is defined as the required processes and services undertaken in order to preserve, repair and care for building's structure and components after completion or after any renovation, repair, refurbishment, conversion or replacement to current standard to enable it to serve its intended function throughout its entire life-span without drastically upsetting its basic features and use (Rakhra, 1983 and Olanrewaju, 2009). From this definition it is clear that maintenance is a value-added initiative and that the users are the main reason for initiating maintenance. Management on the other hand is concerns with the effective and efficient utilization of resource in order to attain the set objectives. Maintenance management is not exceptional to this. Thus building maintenance management can be defined as the process of planning, directing, leading and coordinating organizational resources towards building maintenance so that the building will continue to serve its intended purposes effectively and efficiently. Building maintenance management is goal-driven and, like the general planning process, it includes components for data collection, strategy evaluation, programme selection, implementation and feedback. Maintenance management can, however be classified into maintenance technology, which is the tactical aspect of the process and the main-stream management aspect of the process. The management is a problem-seeking and problem-solving process.

The major emphasis of building maintenance management is on the building being perceived a as a means to an end, not an end in itself and to view the building as an asset or facility rather as a burden. The definition of maintenance management can thus be depicted diagrammatically as shown in Figure 2. This definition suggests that maintenance management is a process that makes use of resources / in put (i.e. time, material, labour and money) and converts (process) them into outcomes (reliability, safety, function, comfort and convenience). At each stage, information it required either as feedback or feed forward. The Figure also suggests that the maintenance management process has no beginning or end. However, in practice when to begin maintenance requires a complex thought process as the decision involves viewing the building, the maintenance and university's corporate objectives concurrently.

The growth of recognition for building maintenance management has evolved to a great extent from government investment in maintenance of public buildings including the university buildings. However, the size and complexities of buildings that require maintenance in Malaysia are huge and are the increase irrespective of the sector. For instance, Ahmad, Nur Azfahani and Nur Haniza (2006) opined that in Malaysia, maintenance problems in buildings are common regardless of their size, location and ownership. Hamilton and Wan Salleh (2001) noted that the list of buildings that

lack proper maintenance in Malaysia is countless. Cursory perusal of Malaysian newspapers will suggest the extent of the unfitness of buildings in Malaysia (The Star, 2007, April 12; New Strait Times, 2007, May 4; The Star, 2008, June 16; The Star, 2007, April 20; New Straits Time , 2008, August 22; New Straits Time , 2008, June 19; New Straits Times, 2008, September 9; The Star, 2008, August, 28; The Star, 2008, June, 4; New Strait Times, 2008, September, 15; New Straits Times, 2008, September, 19). The Ministry of Housing and Local Government received between 2400 and 4500 maintenance complaints each year over the last five years (Chuan, 2008). That means for the last five years it has received more than 20,000 maintenance complaints. Perhaps many were also not reported. Although there is no comparable evidence for other ministries and government agencies, it could be concluded that they are facing a similar degree of maintenance woes. In fact, as a result of the malaise of the incessant maintenance problems facing public buildings, the (immediate) Prime Minister, Datuk Abdullah Badawi, ordered the inspections of all public buildings to ascertain their condition (New Strait Times 2007, May 4). While there is not comparable numerical data on the state of disrepair, decay, deterioration and unfitness of the university buildings in Malaysia, it is possible that they are suffering from a similar degree of care and neglect as other public buildings. This assertion could be further reinforced considering that public universities like public assets depend on government interventions in order to build, operate and maintain their buildings. Public universities depend on their annual budget for operating, development and maintenance costs.

Previous studies on maintenance management of public universities have suggested that the procedure used for university buildings were no different from other public buildings in Malaysia. That is that they are either corrective, time or condition based or their combination. Based on an empirical research, Ishak (2006), observed that the maintenance management procedures for university buildings are planned maintenance, contingency service, corrective, routine and preventive and corrective maintenance. Similarly, Zakaria, Mohamed, Ali (2006a and 2006b) concluded that the ways in which the maintenance of university buildings are managed as corrective, service, preventive and routine. Ruslan (2007) found that universities in Malaysia were still managing their facilities in the traditional ways. The traditional ways he referred to is interpreted to mean the corrective / reactive and condition based. However, while corrective maintenance is a failure based approach, predictive, time and proactive maintenance are condition based. Corrective maintenance is initiated after the building has failed and is intended to restore the building to it original condition. What this means is that maintenance is initiated when the building has failed to perform its intended function due to decay, deterioration or defect or any combination of these. This approach to maintenance is in many cases very expensive, and usually leaves the users less satisfied. Unfortunately, this is the most common approach to maintenance when a building has failed to perform to the expected standard. Condition-based maintenance on the other hands is a type of maintenance initiated as a result of some knowledge of the condition of the building on the basis of inspection prior to failure. As long as the physical parameters, of the building where found to be within specification, it will be considered to be "fine" and no maintenance action will be taken. Maintenance will only be initiated if the physical condition of the building is deteriorating, decaying or failing.

However, stock condition at best provides only a snap shot of the condition of a building during the inspection period. It is difficult to assess the amount of risk posed by an identified non-critical problem to future operations and productivity (Reffat, Gero and Peng, 2004). A non-critical problem during inspection might deteriorate further or become more serious during the actual implementation due to time lapse and error of measurement as a result of visual inspections. Under the condition based maintenance policy the required information is not usually sufficient and convincing to draw a realistic conclusion. The maintenance needs that usually revealed through a condition survey are often in excess of the available budget. The validity and reliability of the determination of the maintenance budget through stock inspection are questionable. Also, O'Dell (1996) opined that stock condition survey could underestimate the volume and costs of maintenance need by as high as 60% of the actual works / costs (Jones, 2002).

Therefore, the existing practices are not value-added approach to maintenance because maintenance depends on the existing of sickness of the building before treatment is recommended. This culminates in poor service delivery and poor user satisfaction and an increase in maintenance backlogs. However, what is critical to the users of client-occupiers of a building is the ability of the building to efficiently and effectively support the performance of the activities within and around the building and not necessarily the physical condition of the building per see (Chapman Beck, 1998; Jones, 2002 and Jones and Sharp, 2007). A building is an enabler and facilitator of human activities. It provides the enabling temperature, humidity, lighting and ventilation necessary for people to live and work productively and efficiently (See also Barrette, 1992 cited in Amaratunga and Baldry, 1998). Users tend not to be satifiifiesd when the building failed to meet their needs and wants. Criteria including temperature, air quality, lighting, noise and comfort in a building increase users' productivity (Leaman, 1995). A success building is therefore, a building that meet (and exceed) the complex requirements of the users. Thus, what is critical in maintenance management is to meet the complex requirements of the users and building itself effectively and efficiently. According to Flanagan and Jewell (2005), a building can still be used even though the fabric has deteriorated significantly. Then (2002) also opined that ultimate essence of building management is the fitness for purpose of the building for the user. The current approaches to building maintenance do

not address maintenance as value added service and failed to consider the perceptions and expectations of the users in decision making. The input, perceptions and expectations of the users and owner-occupiers cannot be compromised if value is to be achieved.

Authors including Seeley (1987), Mills (1994) and Wordsworth (2001) have questioned the validity and of any maintenance policy that does not consider the users in the formulation of the maintenance management system. For instance many parties contributes in the decision making process which govern the design, construction and maintenance of building. But at the end of the line he users are that people that will be affected by such decisions (Mohmoud, 1998). The client is on the one hand, legally responsible for maintenance while, on the other hand, he or she might not be aware of the maintenance problems involved. Thus building ceases to be useful if it cannot provide those functions as required by users. Considering the condition of the building as the main reason for initiating maintenance service is accepting maintenance as a burden that has no value to add to the building. In fact, condition based maintenance system has various other shortcoming including inconsistency in data collection, unrealistic assumption regarding data accuracy, software not being able to interrogate or manipulate data and over emphasized detail that might not even be required (Marshall, Worthing and Thomas, 1996 and Chapman and Beck, 1998). Besides, the physical condition of the building is just a symptom and not the cause of the defects. For efficiency and effective, it is the root causes that require consideration, otherwise wrong solution will be administered to the wrong ailment.

Under the condition based maintenance management, the thrust on combating the physical deterioration and decay of the building not just enhancing its value. Maintenance must be initiated on the basis of the value of the building to the users. In this way the building and associated maintenance will be regarded as investment. Maintenance is a value added initiate to the building and the users. By ensuring that users' activities are well performed. A value based maintenance management system goes beyond the current condition based system and the availability of funds, it involves recognizing maintenance needs as factor of production without the value of a building cannot be sustained. A factor of production enhances productivities and contributes to profit making and saving (Sherwin, 2000). In other words it is a comprehensive and structured system to long – term management of building s as tools for efficient and effective delivery of value to the clients, users and general public. In practice and principle, a maintenance progamme can be initiated at all levels or at any time in the building's life cycle with diminishing level of return. The cost of implementation of the maintenance programme is very low if the maintenance programme proceeds from the value approach to corrective approach, the possibility of positive savings declines substantially and the cost of implementing the maintenance programme increases (Figure 3) (Olanrewaju,2009). The next section draws together the major themes of the paper to highlight the issue that need to be addressed with the respect to value-based maintenance management. The focus of modern forward thinking user and clients extends beyond building technology, corrective and condition based maintenance

3. Synopsis and Further Research

In anticipation of the main research, this paper has outlines a plan to proceed with the research. The shortcomings of the existing practices have been outlined. Lack of sufficient resources has forced government today, to compel their agencies, departments and ministries to maintain their building in the most cost-effective way. As the cost of constructing new facilities increases, maintaining the existing ones has become more prominent as an alternative to the service lives of the buildings. It is not always cost-effective to demolish and reconstruct the existing ones. Maintenance seeks to delay the replacement of building as well as deferring expenditure on new build. A building is the representation of a organization's value systems and the performance of the university building no doubt depict how valuable the university considers the contribution of its buildings towards achieving the core objectives of its business.

Thus there is a need for systematic and holistic maintenance management for building that based on the principle of value. Value involves the amount of money associated with how effectively and efficiently a function or / and service meets the users' or customers expectation (Bateman and Snell, 2009) and perceptions. Buildings are procured or occupy to solve some technical problems as identified by the users / clients. To most not-occupiers clients, buildings are procured to make profit. Building users are the entity or group of individuals or organization who are interested in the adequate functioning of the building. They are affected by the performance of the building and the building is also affected by the activities of users. They have the potential and capability to take a action or decision if their value system is not adequately met. It is the correct functioning of the building that the users desire not the physical condition of the building. To the extent that the building is capable of allowing the user to perform their function, then the building can be said to be valuable. In other words, the building can be said to be adding value to the activities taking place inside or around it. Of what value is a classroom that is not conducive to student learning? The more you meet the user's expectations (measure in terms of quality, speed, reliability, safety and function, comfort, cost, etc) and perception at less cost, the more value is delivered to the users. In other words, the more the users' maintenance performance and expectations are achieved (effectively) with fewer resources (efficiently), the higher the value you add to the maintenance service. The need for value based maintenance management will only intensify as the need for

maintenance increases as maintenance is inevitable, and thus a proactive, efficient and effective approach is highly necessary since the demand of the modern users is for high quality service (and goods) that are delivered on time and which cost less.

In conclusion, this paper has been able to establish that the current maintenance management systems for university buildings in Malaysia are corrective and condition based. It is also established that the condition based maintenance management is reactive rather than proactive and systematic. Considering the condition of the building as the major focus of maintenance is to regard maintenance as burden and to limit maintenance to the technological aspect of the process. Maintenance management is not usually regarded as part of the top management functions or duties in most public organizations rather it often regarded as operational function. It only receives management attention when everything has gone wrong. Users will not be satisfied with the quality of the service they are receiving and the maintenance backlog will be on the increase unless and until the maintenance management reflects the new thinking of the performance of the building which is the desirability of the buildings for the users. The value based maintenance management model takes into account the condition of the buildings, its performance, the users' value systems and the resource used to meet the needs. It involves the efficient and effective utilization of a organization's resources by planning, directing, controlling and organizing in order to meet the maintenance needs of the building users since the ultimate essence of the building is to enable the its users to perform their task effectively and efficiently. Public universities organizations must consider and accept maintenance as factor of production that require strategic attention like other organization's resources.

The prime aim of maintenance management is the effective and efficient allocation of resources to meet maintenance needs. However, the management of the resource has often been based on outcome of the condition survey. On the other hand, maintenance needs established through the condition survey are in fact, often in excess of the available resource among shortcomings. Thus the only feasible alternative method of allocating and determining maintenance resources is to base maintenance needs on the user value systems in terms of whether the building can still continue to support the user functional value system. Buildings are only valuable as a result of the service they provide, and failure will render the existence of the building insignificant if not even useless (Wordsworth, 2001). Therefore, maintenance should be initiated only if the building will no longer facilitate the users in performing their primary tasks. The corporate objectives of a university have to place building performance in a strategic position. Therefore, maintenance is inevitable, and in order to improve and sustain productivities, service delivery and satisfaction of the users, maintenance must be positively managed. The error and inadequacies inherent with the stock condition survey is too much to be ignored. To continue to based on the basis of physical inspection cannot in any way delivered value for the stakeholders and will continue to encourage poor service deliveries.

Maintenance cannot be blamed if things go wrong; rather it is the management of the maintenance process that should be blamed! However, there are limitations to this paper. First, the paper is based on literature. Though the literature are mainly empirical regarding the state of maintenance management of the university buildings in Malaysia, but there is the need for empirical studies to determine if the principle of user value system can form major thrust of initiating maintenance. In, addition, the empirical studies by the previous researchers do not includes most of the public universities, also there could be the tendency that somewhere a or some universities has/have better approach to building maintenance. These issues and more will be addressed in the main research.

References

Ahmad Abdullah Badawi. (2006, February 20). Billions Wasted to Repair Buildings and Amenities. *The Star,* 2006.

Ahmad, R, Nur Azhahani, A and Nur Haniza, I. (2006). The Effects Design on The Maintenance Of Public Housing Buildings In Malaysia-Part One. *Journal of Buildings Engineer*, April, 2006.

Allen, E. (1995 and 2005). *How Buildings Work: the Nature Order of Architecture*, 1st and 2nd edn. Oxford: Oxford University Press.

Bateman, T. S. and Snell, S. A. (2009). *Management*: leading and collaborating in the competitive world, 8th Edition. New York: McGraw Hill / Irwin.

Barrett, P. (1 992). Development of a Post Occupancy Building appraisal Model. In Dilanthi Amaratunga, D and Baldry, D (1998). Appraising The Total Performance of Higher Educational Buildings: A Participatory Approach Towards A Knowledge-base System. *COBRA .98* ISBN 1-873 640-23-4.

Chuan, O. K. (The Minister of Housing and Local Government) (2008, May 9 pN13). Call for Check on Buildings: architects push for inspection every five years. *The Star* pN33.

Hamilton, B and Wan Salleh, W. I. (2001). Maintenance of building important. National House Buyers Association. accessed on 09 / 06 / 08. Available at http://www.hba.org.my/archive/focus/COB/pg1.htm

Jones, K. (2002). Sustainable Buildings Maintenance. In: Kelly, J., Morledge, R. and Wilkinson, S. (2002). (ed) Best Value in Construction. London; Blackwell Publishing.

Jones, K. and Sharp, M. (2007). A New Performance Based Process Model for Built Asset Maintenance. *Facilities*, Vol. 25 No. 13/14, pp525-535.

Wordsworth, P. (2001). *Lee's Building Maintenance Management,* 4th Edn. Oxford: Blackwell Science Limited.

Kalinger, P (1997). The Benefit of Preventive Roof Maintenance, NRCC-40627-5 Building Better Roofs: IRC Technical Seminar, 11 Cities Across Canada September 1996-February 1997, pp1-9. http://nrc-cnrc.gc.ca/ircpubs

Kelly, S. R & Male, S. P. (2001). Value Management in Design and Construction: The Economic Management of Project 1st Edn. London: E and FN Spon.

Leaman, A (1995). Dissatisfaction and office productivity. Facilities. Volume 13 No. 2. pp 13 – 19.

Mills, E. D. (ed. 1994). *Building Maintenance and Preservation; a guide to design and management,* 2nd Oxford: Butterworth-Heinemann 1994.

Mohmoud, M. I. (1998). *Assessment of the Factors Influencing the Maintenance Programme of a Large University Building in Riyadh*", Construction Management and Economic, Vol. 15, issue 6, pp 673-679.

New Straits Times. (9 September, 2008). No you don't: developer get court injunction to stop residents from "taking over condo" p.

New Straits Times. (2007, May 4). Cracks Show Up on Jalan Duta Court Complex Wall p14.

New Straits Times. (2008, August 5). 510 Heritages Building Need Help.

New Straits Times. (15 September 2008). Dirties among seven nations. p16.

New Straits Times. (19 September, 2008) 92 Historical Buildings to Be Restored.

O'Dell, A. (1996). Taking Stock: a Review of stock condition survey methods in the UK. User-oriented and Cost Effective Management, Maintenance and Modernization of Building Facilities, CIB W70, Kesinki 1996 Symposium, 2-3 September 1996.

Olanrewaju, A. A. (2009). Maintenance Management of University Buildings, Article accepted for publication in Journal of Building Appraisal.

Rakhra, A S (1983) Some economic aspects of the rehabilitation of buildings. CIB83. In Proceedings: To Build and Take Care Of What We Have Built With Limited Resources. V. 1A: Renewal, Rehabilitation and Maintenance, 9th CIB Congress. pp77-88. Available at: http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc23437/nrcc23437.pdf Accessed on 11 / 05 / 2008.

Reffat, R. M., Gero, J. S. and Peng, W. (2004). Using Data Mining On Building Maintenance During The Building Life Cycle, *In Proceedings of the 38th Australian and New Zealand Architectural Science Association (ANZASCA) Conference,* School of Architecture, University of Tasmania, Tasmania, Australia, pp.91-97.

Ruslan, B. N. (2007). Campus Facilities Management Experience. In Proceedings of National Assets and Facility Management (NAFAM, 2007). Held on the 13th – 14th of August, 2007. Kuala Lumpur.

Schrag, S., Smith , K and Stollenwerk, B. (2007). Designing for the care and maintenance of building. Accessed on 13 / 05 / 2008. Available at: www.allbusiness.com/energy-utilities/energy-utility-regulation-policy/5496916-1.html - 73k

Seeley, I. H. (1987). *Building Maintenance*, 2nd Edition, Houndmills: Macmillan Press Limited.

The Star (2007, April 12). Immigration Headquarters Havoc: leak on the seventh floor sends water down five levels pN4.

The Star. (16 June 2008). Abandoned Quarters Now An Eyesore. pM12

The Star. (20 April 2007). JB Hospital "sick" again. pN35.

The New Straits Times. (2008, June 19). Downright Filthy Business p5.

The Star. *(28 August 2008). Residents See Red Over Piping Works. pM6.*

The Star. (22 August 2008). Solution To Stinking Woes In Sight. pM8.

The Star (2008, June 4). Ambrin Promises Thorough Check: Inspection team to check 94 public buildings pN14.

Then, S.S. (2002). Post–Occupancy Evaluation (POE) In: Kelly, J., Morledge, R. and Wilkinson, S (2002). (Ed) Best Value in Construction. London; Blackwell Publishing.

Value	=	Benefits / Investment	or	Quality + Functions / Total cost

Figure 1. Value Concept

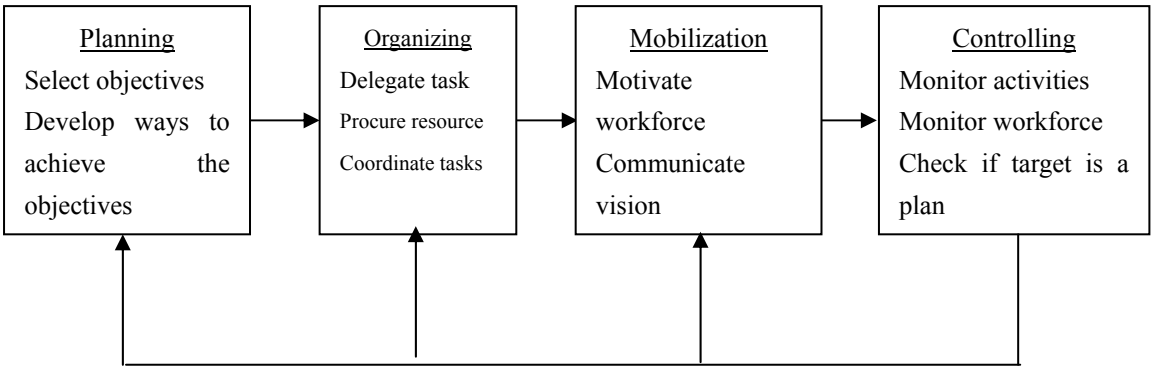

Figure 2. maintenance management definition model

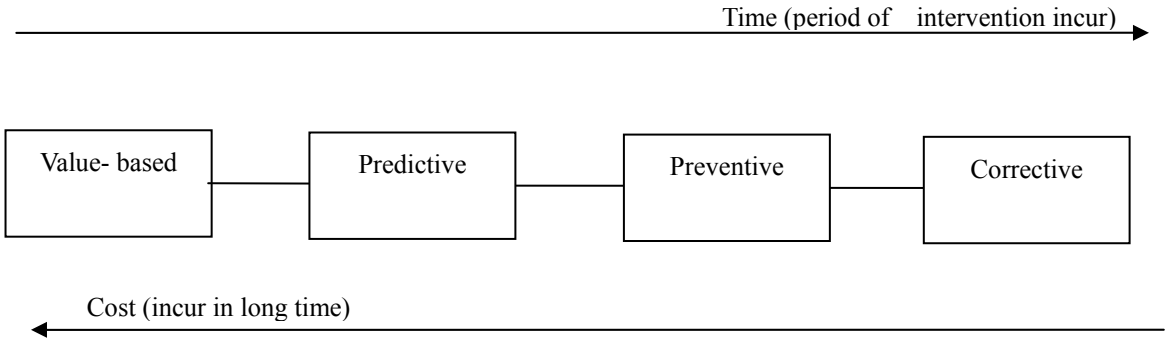

Figure 3. time-cost maintenance intervention framework

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Development of Chinese Light Steel Construction Residential Buildings

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Abstract

Building systems with light steel members, gypsum plasterboards and mineral wool have a wide spread use in the US, Australia and Japan and are gaining market in some European countries. The systems have often load-bearing walls and the floors may be of Light weight steel profiles or concrete. Such systems are suited for industrial production and can contribute to a more efficient building process. This new building technology came to the foreground because of the rapid development in the building industry; surely it has a lot of advantages from the technological point of view, which meet all the requirements these days. But it is more important beside the points of view mentioned above that the construction of these buildings protects the natural environment, and suits the stand points of Sustainable development and guarantees a healthy environment for the users for the whole lifespan of the building. But,these systems are not universally utilized in China. As a matter of fact, they are to agree with the all current situations of China, especially the Light-gauge steel system residence. In the following paper I will justify the existence of light-gauge steel constructional building system in the residential housing with the points mentioned above.

Keywords: Residential construction, Light-Gauge steel, Sustainable development, Building materials

1. Introduction

Light-gauge steel houses are usually built of light thin-walled load bearing structures having different solutions for interior and exterior cladding. This technology is popular and accounts for an important and increasing market share in US, Japan, Australia and Europe. The same method is used for buildings, of small dimensions, of other purposes, that are referred to as small industrial buildings (SIB).

The construction industry in China is fighting with the problem of producing residential buildings that people can afford to live in. Reduced construction costs and more efficient building processes are very much on the agenda together with the restraint of maintained or improved quality. The way forward to these goals is adopting industrial building processes with increased prefabrication. Light-gauge steel system based on old-formed profiles, gypsum boards and mineral wool fit very well into this trend.

2. Light-Gauge Steel Construction

Light-gauge steel Construction is made by a cold-forming process where sheets of steel are passed through a series of roll forming dies to create there desired shade. The desired strength is achieved by a combination of the thickness or gauge of the steel utilized as well as the shape of the member. The various bends in the member's cross-section add to the stiffness and ultimate strength of the piece. Because of the strength advantage produced by this bending process, steel framing material has a strength-to-weight ratio that is very favorable when compared to most other materials. The gauge or thickness of sheet steel ranges from 0.6mm to 1.8mm. By convention the higher the gauge numbers the thinner the steel. The more lightweight non load-bearing interior walls of residential structures are usually made of 0.6mm-gauge steel, while the exterior load-bearing steel studs are usually built from stronger 1.2mm or 1.6mm gauge steel.

To protect steel from rusting, steel is zinc galvanized. This protection is necessary both during storage, construction and while in use to avoid damage and loss of strength due to rusting. Because of that, this system is not a traditional building type in the Chinese circumstances.

The building system characteristics would be summarized as follows:

• The light construction residential house’s frame is assembled from cold formed steel profiles. In the gaps between the elements of the frame heat insulation material is placed and the frame is supplied with surface layers made of various materials, forming a layered structure.

• Generally, the elements of the frame structure are constructed of C and U profiles with a dry, assembly style building technology. Numerous steel fasteners, stiffeners and other complementary profiles are connected to the basic elements of the structure.

• The applied materials filling the gaps between the elements of the frame not only perform heat insulation, but also meet acoustical requirements and they are an efficient fire protection tool. With the application of efficient heat insulation materials a good level of fire protection and an excellent heat and sound insulation can be achieved.

• The inside cover is mostly made by plasterboard. Composite layers by wood as basic material (e.g. OSB) are preferably used as outside wall board cover and floor slabs. With this, we can exploit the advantage of high strength, which provides stiffening function.

• Steel construction components can be pre-measured and precut to exact specifications. On-site adjustments are generally not required.

• Steel components generate minimal waste and all light-gauge steel construction materials are 100% recyclable.

Figs. 1 show steel framed living houses. The structural characteristics are visible in the picture.

3. light-gauge steel assembly methods

The three basic light-gauge steel assembly methods are stick-built construction, panelized systems, and pre-engineered systems. The American Iron and Steel Institute (1994) best describes these three methods as follows:

3.1 Stick-Built Construction

Stick-built construction is virtually the same in wood and steel. This framing method has actually gone through a transformation incorporating many of the techniques used in panelized construction. The steel materials are delivered to the job-site in stock lengths or in some cases cut to length. The layout and assembly of steel framing is the same as for lumber, except components are screwed together rather than nailed. Steel joists can be ordered in long lengths to span the full width of the home. This expedites the framing process and eliminates lap joints. Sheathing and finish materials are fastened with screws or pneumatic pins.

3.2 Panelized Systems

Panelization consists of a system for pre-fabricating walls, floors and/or roof components into sections. This method of construction is most efficient where there is a repetition of panel types and dimensions. Panels can be made in the shop or in the field. A jig is developed for each type of panel. Steel studs and joists are ordered cut-to-length for most panel work, placed into the jig and fastened either by screws or welding. The exterior sheathing, or in some cases, the complete exterior finish, is applied to the panel prior to erection.

Shop panelization can offer several significant advantages to the builder. The panel shop provides a controlled environment where work can proceed regardless of weather conditions. Application of sheathing and finish systems is easier and faster with the panels in a horizontal position. Although the panels must be transported from the panel shop to the job, most often the cost advantages of panelization offset the added transportation costs.

A major benefit of panelization is the speed of erection. A job can usually be framed in about one quarter of the time required to stick-build. When you consider that the exterior finish system may also be part of the panel, the overall time saving may be even greater.

3.3 Pre-Engineered Systems

Because of steel's high strength and design flexibility, innovative systems are possible which are not possible using other materials. Engineered systems typically space the primary load carrying members more than 24 inches on center, sometimes up to 8 feet. These systems use either secondary horizontal members to distribute wind loads to the columns or lighter weight steel in-fill studs between columns. Furring channels used to support sheathing materials also provide a break in the heat flow path to the exterior, which increases thermal efficiency.

Many of the pre-engineered systems provide framing members that are pre-cut to length with pre-drilled holes for bolts or screws. Most of the fabrication labor is done by supplier, allowing a home in as little as one day.

Figs. 2-9show light-gauge steel houses during the building process.

4. Environment and Sustainable development Viewpoints

The ecological approach has pointed out that the current high-level energy consumption, characteristic of people's activity nowadays, the level of exploitation and the pollution of the natural environment lead to a global catastrophe. To decrease this danger, it is absolutely necessary to economize basic materials and energy, as well as extended Sustainable development is required. The macro-level changes mentioned above should appear in all micro-level processes in the construction generally and in the building of concrete houses. This can be put in reality by following the directives of environment friendly, energy-conscious design and building.

In the ecological architecture the most important issue is the enforcement of the viewpoints of sustainable development and public health protection. During the building, the Sustainable development is reachable by reducing significantly the energy consumption by

• Application of building materials with low embodied energy;

• Employment of recyclable building materials;

• Usage of a building technology with low energy need, etc.

The health protection viewpoints have to be taken into consideration during the total lifespan. Naturally, the health protection refers not only to the inhabitants but also to people living in the wider environment and globally to the whole humanity. The principles of health protection suggest the application of possibly natural materials and technologies, which are absolutely harmless to people.

5. Feasibility analysis in China

Light construction residential building is more and more frequently used in China.Although the application quantity is still low, in the last decade it came to the foreground due to numerous advantages.

• As the rapid development of China's iron and steel industry, steel production in 2004 reached 200 million t, as the world's largest producer of steel. The variety and standard of steel are to increase which supply the matter foundation of the development of light-gauge steel structure residence.

•The government attaches great importance to the development of steel construction, the Ministry of Construction in the new revised "Building Technology Policy", clearly a positive development. Released in 2002, "Residential Steel Industry Technology Guide" for the development of light steel housing policy and technical support to ensure that this will be a positive role in promoting the development of China's steel building industry.

•Cold-formed light-gauge steel structure residence meets the requirement of building industry. Building industry is the sustainable development of cities to further deepen.

6. Problems of light steel residence development

Although the light steel is the best choice to replace the existing masonry and concrete materials, the current system of light steel structure residential applications in China is limited. Rural and small towns have not yet applied. The main reason to explore as follows:

•Light steel frame components are light-gauge steel structure' key materials. Especially, they are about 1 mm with C and U-shaped steel, the current domestic production of such components can be very few manufacturers. A serious shortage of production is to result in excessive cost.

•Their standard is not in conformity with the norms of domestic. Because of this limit, light steel structure residential steel building will be a significant increase in its cost; it lost the competitiveness of traditional architecture.

•The traditional concept of consumer. They are not familiar with the new structure residence, so resist.

7. Advices

•Introducing foreign advanced technology, suited to China's production of cold-formed steel component system and the production line, large-scale promotion in the domestic.

•Research institutes, universities and enterprises to actively carry out cold-formed steel residential component parts of the theoretical and experimental research. And to standardize the form of the final set, for design engineer to based on.

•Fundamentally change the traditional residential impression of light steel structure residence to people, so that the advantages of light steel structure residential is known by people.

It can be predicted that light steel structure residential will be a wide range of development in the 21st century of China.

References

American Iron and Steel Institute. (1994). Build it with steel - An introduction to residential steel framing.

Annamária DUDÁS. (2003). Light steel structure in residential house construction [J]. *Periodica Polytechnica Ser*, 2003, 47(1): 133~136.

Bruce W.Bateman. (1997). Light-Gauge Steel Verses Conventional Wood Framing In Residential Construction [J]. *Journal of Construction Education Copyright*, 1997, 2(2): 99~108.

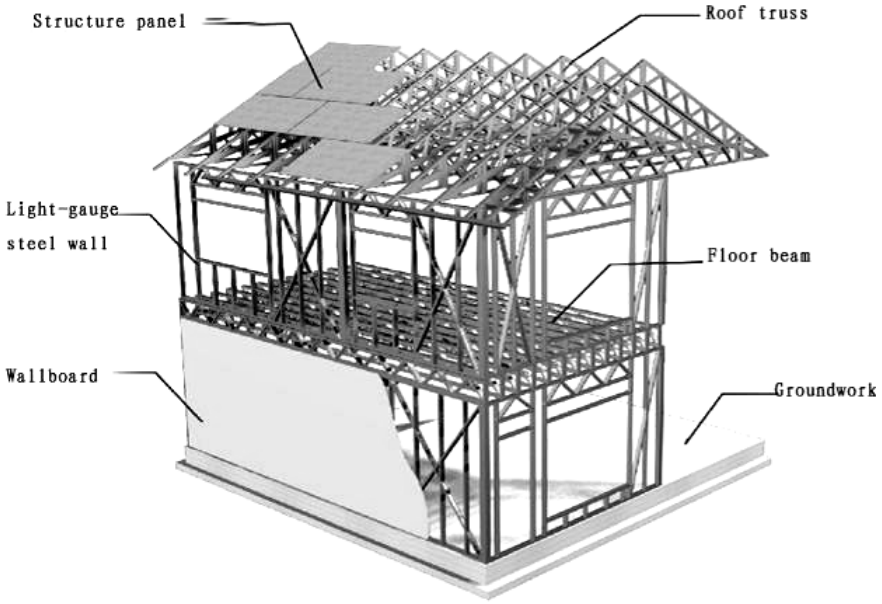

Figure 1. steel framed living houses

Figure 2. The basis of the construction

Figiure 3. The laying of light steel floor joist

Figure 4. Lifting roof truss

Figure 5. Housing roof truss

Figure 6. Retaining wall skeleton

Figure 7. The laying of roof and wall panels(OSB)

Figure 8. Fixed ceiling light steel frame

Figure 9. Light-gauge steel residential

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Ethnic and Gender Diversity in Boards of Directors and Their Relevance to Financial Performance of Malaysian Companies

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Abstract

The purpose of this paper is to empirically examine the effect of demographic diversity on boards of directors with regard to firm financial performance. This paper uses secondary data of non-financial listed companies over the period 2000 to 2006. Relevant concepts, propositions, hypotheses and control variables are specially developed to meet our requirements. Demographic diversity is represented by ethnic and gender diversity and performance is measured by return on asset (ROA) and return on equity (ROE). A series of OLS regressions using on the cross-sectional data are also presented. The results seem to be quite inconsistent to prove the relevance of diversity among the board members with regard to financial performance.

Keywords: Gender and ethnic diversity, BODs, Performance

1. Introduction

Despite the major roles carried out by managers at strategic level, the boards of directors also have the primary duty and responsibility for the corporation's performance (Fischel & Bradley, 1986). The literature concerning the roles of the board of directors encompasses stewardship theory and the agency theory. The stewardship theory offers the positive effects of managers' participation in organizations (Donaldson, 1990; Donaldson & Davis 1991). Agency theory emphasizes on the agent – principal relationship which may cause agency cost as managers tend to place their personal goals ahead of the corporate goals (Jensen & Meckling, 1976, Eisenhardt, 1989). Admittedly, the board members have the obligations in maximizing shareholders' wealth through an effective monitoring or controls over top management (Kose & Senbet, 1998). The board members are also perceived to be an important device for upholding an effective corporate governance to ensure as there is a need to create adequate returns for shareholders (Vafeas, 1999; Weir & McKnight, 2001; Coles et al., 2001). Fundamentally, the resource dependence theory proposed that corporate boards are a mechanism for managing external dependencies (Pfeffer & Salancik, 1987), reducing environmental uncertainty (Pfeffer, 1972) and reducing the transaction costs associated with environmental interdependency (Williamson, 1984). In the case of Malaysia, after the 1997 Asian financial crises, the Malaysian Code of Corporate Governance has hinted on the importance of board structure, board size and independent board of directors since year 2000. And, the Bursa Malaysia has also started limiting on the number of directorship of a person starting since 2002.

Investigation on the characteristics of the top level management that mainly involves top managers and board of directors (BODs) is always the main discussion be it in the academic or corporate world. It will be of great value when we link this discussion to firm performance (Kakabadse & Kakabadse, 2006; Kakabadse et.al., 2006; Cadbury, 1992; Dahya & Travlos, 2000; Kroll, Walters & Le, 2007; Auden, 2006). Undoubtedly, women's and multi-ethnic groups' involvement in the top level management has become a very important component in understanding characteristics of the top level management including the board of directors. However, relating the characteristics of the BODs to firm

performance will be a valuable contribution. It has been noted that quite a number of studies have been carried out in this area (e.g Burke, 1997; Burke & Nelson, 2002; Carter, Klenke, 2003).

2. Focus of the Study

The demographic characteristics on top management team (TMT) includes age, functional background, education, tenure, (Hambrick & Mason, 1984), who dealed with diversity within top management and its impact on firm performance that is strongly linked to the **Upper Echelon Theory**. They insisted that top management's characteristics (e.g. demographic) influence the decisions that they make and therefore the actions adopted by the organizations that they lead. It occurs because demographic characteristics are associated with many cognitive bases, values and perceptions that influence the decision making of top management. Top management members could with greater demographic diversity, influence decision making process in the top management and positively contribute to firm performance. The basic foundation of this theory could be linked to the earlier concepts on the characteristics at the top management and competitive behaviours (Cyert & March, 1963). Thus, firm performance could be positively impacted by the competitive behaviours at top level of an organization. In the case of BODs, diversity enhances greater creativity, innovativeness and quality decision making, thus this study expects the similar outcome at strategic level particularly involving the boards of directors (Zahra & Pearce, 1989) since boards are the most influential actors, boards are also to carry out the monitoring role representing shareholders (Hambrick 1996).

Research shows that increasing diversity on boards of directors would be beneficial to organization in terms of gaining critical resources (Pfeffer & Salancik, 1978) and where corporate governance is concerned, benefits at strategic level are positively related to diverse top management (Eisendardt & Bougeois, 1988). Occupational diversity among board members is also positively related to performance in the context of social obligation (Siciliano, 1996). Zander (1993), stresses that efforts must also be taken to make fullest use of the talents of board members. The presence of the demographic heterogeneity at top management level is expected to increase firm performance, hence, heterogeneity is suitable for complex, ambiguous business operations and the decision making processes are structured in nature whereas, homogeneity in top management is more effective especially when faced with unstructured decision making processes (Hambrick & Mason, 1984).

This paper expands the boundary of the upper echelon theory and its application and implications on firm performance. However, instead of focusing on age, functional background, educational background and tenure of the individual manager as most researchers have done earlier, this study focuses the proportion (in percentage) of demographic diversity based on gender and ethnicity among board members and its implications on firm performance. As clarified in the literature, demographic diversity includes gender, age, race and ethnicity whereas, cognitive diversity includes knowledge, education, values, perception, affection and personality characteristics (Maznevski, 1994; Pelled, 1996; Boeker, 1997; Watson et al., 1998; Peterson, 2000; Timmerman, 2000). There have been interesting contemporary studies on demographic diversity in relation to boards of directors and firm performance (Lee & Far, 2004; Evans & Carson, 2005; Bergen & Massey, 2005; Roberson & Park, 2007; Erchardt, et al., 2003; Certo et al., 2006; Carson, et al., 2004;).

This study is therefore to investigate the impact of diversity (demography) among the boards of directors on firm performance. Some related discussion has recently been presented by Maran (2008) and Maran & Indraah (2008). Hence, the purpose of this study is to empirically examine the relationship between demographic diversity (gender and ethnic diversity) on boards of directors with firm performance (Certo et.al., 2006, Kroll, Walters & Le, 2007; Auden, 2006).

3. Definition

Ethnic groups are defined as 'people of other countries' (Yin, 1973) but however, ethnic groups do not necessarily share a country of origin but instead share a sense of common political or cultural origin (Capehart, 2003). Hassan, Samian and Silong (2005) *…managing diversity is very much based on tolerance and respect …to preserve inter-ethnic harmony.*

4. Theoretical Argument on Diversity

Studies reveal that the relationship between diversity and organizational or financial performance can be either positively correlated or negatively correlated and some studies show give inconclusive results. Diversity within the senior management ranks was evidenced in higher perceived levels of overall performance, profitability and return on equity (Allen, Dawson, Wheatly & White, 2008). Some empirical findings indicate that diversity results in greater knowledge, creativity and innovation and thus, organizations tend to become more competitive (Watson et al., 1993) and diversity also able to attract and retain the best talent available; reduced costs due to lower turnover and fewer lawsuits, enhanced market understanding and marketing ability, better problem solving, greater organizational flexibility and better overall performance (Coz & Blake, 1991; Griscombe & Mattis, 2002) via improvement in decision making at strategic level (Bantel, 1993). Siciliano (1996) argues that board diversity offers positive results in

performance. This is also supported by Eisenhardt et al., (1998), Smith et al., (1994), Carpenter (2002) and Greening and Johnson (1996). Heterogeneity is positively linked to better problem solving and offering creating solutions (Michael & Hambrick, 1992).

Meantime, some argue having homogeneous management team would be more beneficial with regard to firm performance (Wiliams & O'Reilly, 1998), homogeneous groups can also result in better performance (Murray,1989). In fact, heterogeneity tends to lead to conflicts and negatively affect the effectiveness of communication in top management (Pelled at al., 1999; Amason, 1996; Carpenter, 2002). Besides this, racial and gender diversity can have negative effects on individual and group outcomes in certain instances (Miliken & Martins, 1996). For example, group members who differ from the majority tend to have lower levels of psychological commitment and higher levels of turnover intent and absenteeism. It should be noted that the upper echelon diversity is associated with the demographic diversity of the workforce, with evidence of homo-social reproduction taking place in organizations, particularly with regard to gender and race (Nishii, Gotte & Raver, 2007)

5. Hypotheses

The Upper Echelon Theory by Hambrick and Mason (1984) becomes an important input in relating heterogeneity in top management team (TMT) to firm performance. The boards of directors (BODs) that can be viewed in the same context as TMT (Hofman, Lheureux & Lamond, 1997) and it should be noted that it is not organizational performance rather financial performance that is being investigated here and demographic diversity is represented by gender and ethnic diversity (Roberson & Park, 2007; Conyon & Mallin, 1997; Daily et al., 1999; Zander, 1979; Costa & Kahn, 2003; Kang & Cnaan, 1995; Rutledge, 1994; Widmer, 1987; Carson, Mosley & Boyar, 2004). Therefore, these arguments allow us to develop a set of directional hypotheses that support a strong correlation between demographic diversity among the board members with firm financial performance, thus the following hypotheses are proposed:

Hypothesis1: Gender diversity among board members is positively correlated with firm financial performance

Hypothesis 2: Ethnic diversity among board members is positively correlated with firm financial performance.

6. Methods and Measures

Top 100 Malaysian listed companies from the non-financial sector were selected for this study over the period 2000 to 2006 (Appendix 1). The selection was based on their market capitalization. This sample represented the overall performance of the main board as they accounted for almost two-thirds the total market capitalization on the main board. A financial database (OSIRIS) and companies' annual report were used for data collection. The main focus was to detect the effect of gender and ethnic diversity on board of directors (BODs) with regard to firm financial performance from year 2000 to 2006. This period reflects the beginning of the corporate governance enhancement in Malaysia (The Malaysian Code on Corporate governance, 2000). The dependent variable was financial performance, independent variables were gender and ethnic diversity and the control variables were board size, firm size and firm age. Besides this, previous years' performance was also used as part of the control variables.

$$\mathbf{Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_n X_n + \varepsilon}$$

$$\mathbf{Performance = \alpha + \beta_{gender} + \beta_{ethnic} + \Sigma\beta_{control\ variables}}$$

The dependent variable, ROA, (net Income divided by total asset), ROE, return on equity (net Income divided by total equity) and was a measure used to measure firm financial performance (Thomas & Ramaswamy, 1994, Certo et al., 2006). The use of two different dependent variables was to check on the consistency of the regression results as both were widely adopted by researchers. The independent variables, gender and ethnic diversity on BODs were measured using a ratio scale. Gender and ethnic diversity on BODs were determined by taking female directors and non-Malay directors divided by total board directors. The control variables; board size was determined by the number of directors sitting on the board, firm total asset was a measure for firm size, firm age refers to number of years of business operations and performance of year 2000 and 2003. (Roberson & Park, 2007; Jehn & Bezrukova, 2004; Cohen & Cohen, 1975, Erchardt et al., 2003, Rosenthal & Rosnow, 1984).

7. Results

This study is to examine the effect of demographic diversity in boards of directors (BODs) on firm financial performance. The correlation results using the data of year 2006 are shown in Table 1. Table 2 shows the regression results using two different dependent variables (ROA and ROE) based on the cross-sectional data from year 2000 to 2006.

Table 1 reveals that ethnic diversity is significantly (positively) correlated with performance (ROA) at 0.05 (0.263), significant correlation can also be found with ROA in year 2000 and 2003. Thus, the effect is consistent with performance at different periods. In addition, gender diversity was not correlated with performance and this is a kind of early signal that gender diversity might not create any impact on firm financial performance. As for the

multi-collinearity effect, it was verified that the VIFs (Variance-inflating factor) for all the independent variables were between 1.0 and 1.3

Based on the findings in Table 2, as expected, gender effect did not have any impact on firm financial performance throughout the years except in year 2005, where it registered a positive relationship with ROE. Hence, hypothesis 1 is not supported. However, ethnic diversity did create some significant impact on financial performance in the second half of the period from 2004 to 2006. It is quite disappointing as we fail to obtain consistent results over the seven year period, however it could be viewed that ethnic diversity with regard to firm financial performance is becoming increasingly important in boards of directors. Thus, hypothesis 2 is partially supported. The graphical expressions relating to the correlation between ethnic diversity (EDIVBOD) and performance (ROA and ROE) is shown in Figure 1 and 2 below. Linear relationship between ethnic diversity and ROA is slightly steeper as compared to relationship between ethnic diversity and ROE, which is slightly flatter.

8. Discussions

In the case of board of directors (BODs), demographic diversity partially influenced firm financial performance. It is quite surprising when gender effect among the board members did not turn out to be significant with regard to financial performance. However, to a certain extent, ethnicity in boards of directors created a significant impact on firm financial performance. These findings are quite consistent with our earlier study (Maran & Indraah, 2009). Hence, ethnic diversity could be used an effective way to improve on corporate governance among the listed companies in the event of economic instability (Mitton, 2002). It should be added here that heterogeneity in boards of directors would further enhance the quality of corporate decisions as the members on the boards are directly involved in issuing, restructuring, takeover exercises, introducing measures to enhance regulatory, transparency, accountability and independence. Though women's role was not felt in boards of directors, again it could be argued that the effect was only for a short run.

9. Limitations

Some limitations or potential weaknesses in this study must be addressed. First, homogeneous characteristics of the companies selected might have been violated as there various industries involved. The sample size could be relatively smaller and the data collected involved only large companies. There could be different effects on different sizes of company. There could also be a curvilinear relationship between demographic diversity and financial performance. This means diversity may result in adverse results for a certain period, followed by indifferent results, then positive relationship with regard to performance.

10. Conclusions

Despite the inconsistent findings, we believe this study has offered some meaningful information especially in terms our readiness and the need to emphasize on the gender and ethnic diversity in boards of directors. Admittedly, this study fails to draw a conclusive set of findings on the relevance of heterogeneity among board members. However, it is believed that many companies on the other hand do prefer homogeneity at top level management especially for decision making process. Probably, more research should be carried on different samples involving different industries to further verify the results.

References

Allen, R.S., Dawson, G., Wheatly, K. and White, C.S. (2008). Perceived diversity and organizational performance. *Employee Relation, 30*(1), 20-33.

Amason, A. C. (1996). Distinguishing the effects of functional and dysfunctional conflict on strategic decision making: Resolving a paradox for top management teams. *Academy of Management Journal*, *39*, 123-148.

Auden, W. C., Shackman, J. D. and Onken, M. H. (2006). Top management team, international risk management factor and firm performance. *Team Performance Measurement*, *12, 7*(8), 209-224.

Bantel, K. (1993). Strategic clarity in banking: Role of top management-team demography. *Psychology Reports*, *73*, 1187-1203.

Bergen, V. C. W. and Massey, J. (2005). Workforce diversity and organizational performance. *Equal opportunities International*, *24*, 1-16.

Bernardi, R. A., Bean, D. F. and Weippert, K. M. (2002). Signaling gender diversity through annual report pictures: a research note on image management. *Accounting, Auditing and Accountability Journal, 15* (4), 609-616.

Boeker, W. (1997). Executive migration and strategic change: The effect of top manager movement on product-market entry. *Administrative Science Quarterly*, *42*, 213-237.

Burke, R.J. (1997). Women on corporate boards of directors a needed resource. *Journal of Business Ethics,* 16, 909-15.

Burke, R. and Nelson, D. (2002). *Advancing women in management: Progress and prospects. Advancing Women's Careers*. Oxford: Blackwell.

Cadbury, A. (1992). Report of the committee on the financial aspects of corporate governance, Gee & Co., London.

Carpenter, M. A. (2002). The implications of strategy and social context for the relationship between top management team heterogeneity and firm performance. *Strategic Management Journal*, *23*, 275-284.

Carson, C. M., Mosley D. C. and Boyar, S. L. (2004). Performance gains through diverse top management teams. *Team Performance Management*, *10*, 121-126.

Certo, S. T., Lester, R. H. and Dalton, D. R. (2006). Top management teams, strategy and financial performance: A Meta-analytic examination. *Journal of Management studies*, *43*, 813-839.

Cohen, J. and Cohen, P. (1975). *Applied multiple regression/correlation analysis for the behavioural sciences*. Hillsdale, NJ: Lawrence Erlbaum.

Coles, J. W., Mc Williams, V. B. and Sen, N. (2001). An examination of the relationship of governance mechanisms to performance. *Journal of Management*, *27*, 23-50.

Conyon, M. and Mallin, C. (1997). Women in the board room: Evidence from large UK companies. *Corporate governance, 5*, 112-117.

Costa., Dora. and Mathew, E. K. (2003). Cowards and heroes: Group loyalty in the American Civil War. *Quarterly Journal of Economics*, *118*(2), 519-548.

Cox, T. and Blake, S. (1991). Managing cultural diversity: Implication for organizational effectiveness. *Academy of Management Executive, 5* (3), 45-55.

Cyert, R. M. and March, J. G. (1963). *A Behavioral theory of the firm*. New Jersey:Prentice Hall.

Dahya, J. and Travlos, N. G. (2000). Does one man show pay? Theory and evidence on the dual CEO revisited. *European Financial Management, 6*(1), 88-98.

Daily, C., Certo, S. and Dalton, D., (1999). A decade of corporate women: some progress in the board room: None in the executive suite. *Strategic Management Journal, 20*, 93-99.

Donaldson, L. (1990). The ethereal hand: Organizational economics and management theory. *Academy of management review, 15*, 369-381.

Donaldson, L. and Davis, G. H. (1991). Stewardship theory or agency theory: CEO governance and shareholder returns. *Australia Journal of management*, *16*, 49-64.

Donaldson, L. (1994). Board and company performance: Research challenges the conventional wisdom. *Corporate governance: An International review*, *2*(3), 151-160.

Eisenhardt, K. M. and Bougeois, L. J. (1988). Politics of strategic decision making in high-velocity environments: Toward a midrange theory. *Academy of Management Journal*, *31*(4), 737-770.

Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of management review*, 1*4*, 57-74.

Erchardt, N. L., Werbel, J. D. and Shrader, C. B. (2003). Board of director diversity and firm financial performance. *Corporate Governance*, *11*, 102-111.

Evans, W. R. and Carson, C. M. (2005). A social capital explanation of the relationship between functional diversity and group performance. *Team Performance Management*, *11*, 302-314.

Fischel, D. and Bradley, M. (1986). The role of liability rules and the derivative suit in corporate law: A theoretical and empirical analysis. *Cornell Law Review*, *71*, 261-283.

Greening, D. W. and Johnson, R. A. (1996). Do managers and strategies matter? A study in crisis. *Journal of Management Studies, 33*, 25-51.

Griscombe, K. and Mattis, M. C. (2002). Leveling the playing field for women of color in corporate in management : Is the business case enough?. *Journal of Business Ethics, 37*, 103-109.

Hambrick, D. C. and Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, *9*, 193-206.

Hambrick, D. C., Cho, T. S. and Chen, M. (1996). The influence of top management team heterogeneity on firms' competitive moves. *Administrative Science Quarterly*, *41*, 659-685.

Hassan, Z., Samian, A. L. and Silong, A. D. (2006). *Readings on ethnic relations in a multicultural society: Perspectives and research on national unity and integration*. Serdang: Universiti Putra Malaysia.

Hoffman, J. J., Lheureux, R. A. and Lamont, B. T. (1997). The effect of inner and outer TMT size on the performance of international firms. *Journal of Managerial Issues*, *9*, 121-135.

Jehn, K. A. and Bezrukova, K. (2004). A field study of group diversity, workgroup context, and performance. *Journal of Organizational Bahavior*, *25*, 703-729.

Jensen, M.C. and Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economies, 3*, 305-330.

Kakabadse, N. K. and Kakabadse, A. P. (2006). Chairman of the board: demographics effects on role pursuit. *Journal of Management Development, 26*(2), 169-192.

Kakabadse, N. K., Kakabadse, A. P. and Barrat, R. (2006). Chairman and chief executive officer (CEO): That sacred and secret relationship. *Journal of Management Development, 25*(2), 134-50.

Kang, C. H. and Cnaan, R. A. (1995). New findings on large human service organization boards of trustees. *Administration in Social Work, 19*, 17-44.

Klenke, K. (2003). Gender influences in decision making processes in top management teams. *Management Decision*, 41(10), 1024-1034.

Kose, J. and Senbet, L. (1998). Corporate governance and board effectiveness. *Journal of Banking and Finance*, *22*(4), 371-403.

Kroll, M., Walters, B. A. and Le Son, A. (2007). The impact of board composition and top management team ownership structure on post-IPO performance in young entrepreneurial firms. *Academy of management Journal, 50*(5), 1198.

Lee, C. and Farh, J. L. (2004). Joint effects of group efficacy and gender diversity on group cohesion and performance. *Applied psychology: An International Review*, *53*, 136-154.

Maznevski, M. L. (1994). Understanding our differences: Performance in decision- making groups with diverse members. *Human Relations*, *47*, 531-552.

Maran, M. (2008). Ethnic diversity on boards of directors and its implications on firm financial performance. *The Journal of International Social Research*, *1*(4), 431-445.

Maran, M. and Indraah, K. (2008). Demographic diversity, top management team, board of directors and firm financial performance: Malaysian evidence. *Proceedings of the Applied International Business Conference 2008*, 291-303, Labuan, Malaysia: Labuan School of International Business and Finance.

Maran, M. and Indraah, K. (2009). Demographic diversity in top level management and its implications on firm financial performance: An empirical discussion. *International Journal of Business Management*, 4(6), 176-188.

Michel, J. G. and Hambrick, D. C. (1992). Diversification posture and top management team characteristics. *Academy of Management Journal*, *35*, 9-37.

Milliken, F. and Martins, L. (1996). Searching for common threads: Understanding the multiple effects of diversity in organizational groups. *Academy of Management Review*, *21*, 402-434.

Mitton, T. (2002). A Cross-firm analysis of the impact of corporate governance on the east asian financial crisis. *Journal of Financial Economics*, *64*, 215-241.

Murray, A. (1989). Top Management group heterogeneity and firm performance. *Strategic Management Journal*, 10, 125-141.

Nishii, L.H., Gotte, A. and Raver, J.L. (2007). Upper echelon theory revisited: The relationship between Upper echelon diversity, the adoption of diversity practices and organizational performance. CAHRS Working Paper Series.Cornell University.

Pelled, L. (1996). Demographic diversity, conflict and work group outcomes: An intervening process theory. *Organization Science*, *7*, 615-631.

Pelled, L. H., Eisenhardt, K. M. and Xin, K. R. (1999). Exploring the black box: An analysis of work group diversity, conflict and performance. *Administrative Science Quarterly*, *44*, 1-28.

Petersen, R. (2000). The management of a diverse workforce in the business environment of Israel and possible applications for South Africa. *Dissertation Abstracts International Section B: The Science and Engineering*, *60*, 4284.

Pfeffer, J. (1972). Size and composition of corporate board of directors. *Administrative Science Quarterly, 21*, 218-228.

Pfeffer, J. and Salancik, G. R. (1978). *The external control of organizations: A resource dependence perspective*. New York: Harper & Row.

Roberson, Q. M. and Park, H. J. (2007). Examining the link between diversity and firm performance: The effects of diversity reputation and leader racial diversity. *Group & Organization Management, 32*, 548-568.

Rosenthal, R. and Rosnow, R. L. (1984). *Essentials of behavioural research*. NY: McGraw Hill.

Rutledge, J. M. (1994). *Building board diversity*. Washington DC: National Center for Non-Profit Boards.

Siciliano, J. (1996). The relationship of board member diversity to organizational performance. *Journal of Business Ethics*, *15*, 1313-1321.

Smith, K. G., Smith, K. A., Olian, J. D., Sims, H. P., O'Bannon, D. P. and Scully, J. A. (1994). Top management demography and process: the role of social integration and communication. *Administrative Science Quarterly*, *39*, 412-38.

Thomas, A. S. and Ramaswamy, K. (1994). Matching managers to strategy: An investigation of performance implications and boundary conditions. *Australian Journal of Management*, *19*(1), 73-93.

Timmermen, T. (2000). Racial diversity, age diversity, interdependence and team performance. *Small Group Research*, *31*, 592-606.

Vafeas, N. (1999). Board meeting frequency and firm performance. *Journal of Financial Economics*, 53, 113-142.

Watson, E., Kumar, K. and Michaelsen, L. (1993). Cultural diversity's impact on interaction process and performance: Comparing homogeneity and diverse task groups. *Academy of Management Journal*, *36*, 590-603.

Watson, W., Johnson. L. and Merritt, D. (1998). Team orientation, self orientation and diversity in task groups: Their connection to team performance over Time. *Group and Organization Management*, *23*, 161-189.

Weir, C., Laing, D. and McKnight, P. J. (2001). An empirical analysis of the impact of corporate governance mechanisms on the performance of UK firms, Working Paper, http://www.ssrn.com

Widmer, C. (1987). Minority participation of boards of directors of human services: Some evidence and suggestions. *Journal of Voluntary Action Research*, *16*(4), 33-44.

Williams, K.Y. and O'Reilly. (1998). Demographic and diversity in organizations: A review of 40 years of research, in Staw, BM and Cummings LL(eds). *Research in Organizational Behaviour*, 20, 77-140.

Williamson, O. (1984). Corporate Governance. *Yale Law Journal, 93,* 1197-1229.

Yin, R. (1973). Identity definition and maintenance. In R. Yin (Ed), Race, creed, Color or national origin: A reader on racial and ethnic identities in American society: pp 45-48. Itasca, IL:F.E. Peacockk Publishers, Inc.

Zahra, S. and Pearce, J. (1989). Boards of directors and corporate financial performance: A review and integrative model. *Journal of Management*, *15*, 291-344.

Zander, A. (1979). The psychology of group processes. *Annual Review of Psychology*, *30*, 417-51.

Zander, A. (1993). *Making boards effective: The dynamics of non profit governing boards*. San Francisco, CA: Jossey Bass.

Table 1. Mean and Correlation results

Variables	Mean	1	2	3	4	5	6	7	8	9	10
1. Gender	0.135	1									
2. Ethnicity	0.525	-.073	1								
3. Board size	8.320	-.073	.008	1							
4. Firm size[a]	6.238	.016	-.113	.070	1						
5. Firm age[b]	30.520	-.121	-.026	-.157	.013	1					
6. ROA	3.815	.052	**.263****	.111	-.014	-.185	1				
7. ROE	7.895	-.019	.160	.050	.017	-.102	**.546****	1			
8. ROA'00	5.053	.103	**.243***	-.016	-.135	-.148	**.417****	**.362****	1		
9. ROE'00	9.001	.129	.186	-.068	-.034	-.103	**.275****	**.266****	**.886****	1	
10. ROA'03	5.627	-.010	**.203***	.080	**-.211***	-.187	**.561****	**.392****	**.617****	**.435****	1
11. ROE'03	9.842	.012	.186	.044	**-.197***	-.170	**.263****	**.354****	**.442****	**.459****	**.770****

a in billions, b in years, * $p < 0.05$, ** $p < 0.01$

Table 2. Parameter Estimates from Cross-sectional Regressions of Financial Performance on Demographic Diversity (2000 – 2006)

Independent Variables	2000		2001		2002		2003		2004		2005		**2006**	
	ROA	ROE	ROA	ROE	ROA	ROE	ROA	ROE	ROA	ROE	ROA	ROE	**ROA**	**ROE**
Constant	4.701	**11.451**[a]	**6.176**[a]	**16.123**[a]	4.824	11.151	1.682	3.260	-1.388	-.934	-5.614	.336	**-9.677**[a]	-3.848
Gender	4.452	14.616	11.891	8.932	-3.384	2.317	.566	1.663	-4.407	-36.139	16.197	**34.977**[b]	9.801	-10.072
Ethnicity	3.182	3.810	1.751	3.588	1.462	3.657	1.125	1.591	**8.781**[c]	**17.714**[c]	**10.626**[c]	**12.169**[b]	**7.063**[a]	6.377
Board size	.092	-.401	-.127	-.765	.264	-.135	.259	.510	.379	.908	.297	-.217	.305	.255
Firm size	**-.474**[b]	-.538	-.260	-.508	-.280	-.452	-.112	-.039	.021	**.676**[a]	.019	.075	.086	.109
Firm age	-.054	-.058	-.056	-.087	-.088	-.189	-.024	-.039	-.017	-.096	-.007	-.007	-.046	-.045
ROA'00							**.417**[c]						.123	
ROA'03													**1.100**[c]	
ROE'00								**.474**[c]						.178
ROE'03														**.685**[b]
R-square (%)	9.9	6.0	7.4	7.5	4.5	3.6	41.0	23.2	9.2	13.6	12.8	13.0	36.8	15.7
F-test	**.078**[a]	.312	.195	.192	.488	.618	**.000**[c]	**.000**[c]	.102	**.016**[c]	**.023**[b]	**.020**[b]	**.000**[c]	**.024**[b]

Dependent variable: Performance, a ~ $p < 0.10$, b ~ $p < 0.05$, c ~ $p < 0.01$

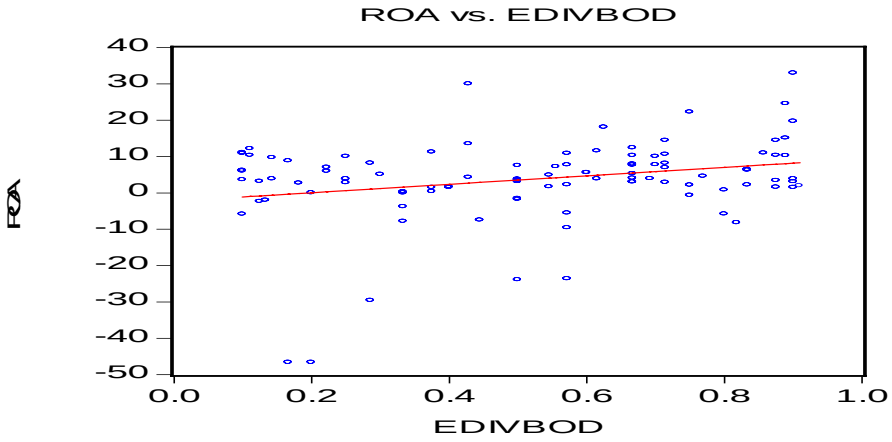

Figure 1. Scatter fit between ethnic diversity and ROA

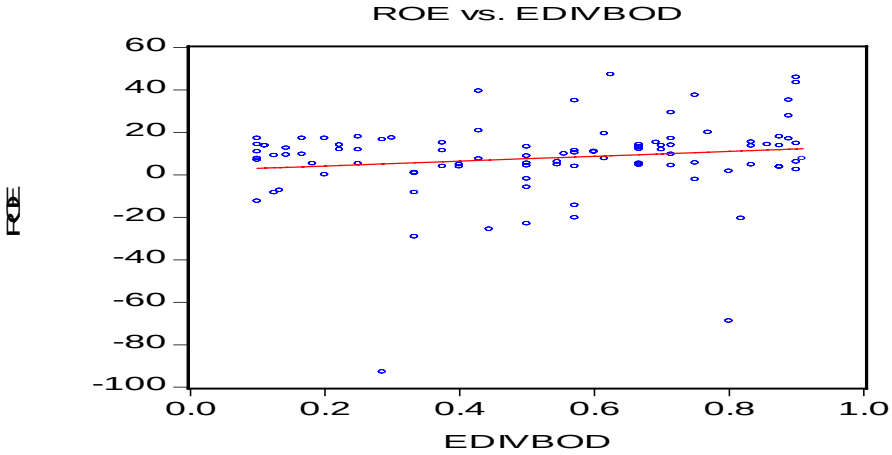

Figure 2. Scatter fit between ethnic diversity and ROE

Appendix 1. Top 100 non-financial companies

No	Company	No	Company
1	AKN Technology Bhd	51	Malayan United Industries Bhd
2	Batu Kawan Bhd	52	Malaysian Airline System Bhd
3	Amway (Malaysia) Hldgs Bhd	53	Malaysian Mosaics Bhd
4	APM Automotive Holdings Bhd	54	Malaysian Oxygen Bhd
5	Asiatic Development Bhd	55	Malaysian Pacific Ind Bhd
6	Bandaraya Developments Bhd	56	Marco Holdings Bhd
7	Berjaya Land Bhd	57	MISC Bhd
8	Berjaya Sports Toto Bhd	58	MMC Corporation Bhd
9	Bintulu Port Holdings Bhd	59	Mulpha International Bhd
10	Boustead Heavy Industries Corp Bhd	60	NCB Holdings Bhd
11	Boustead Holdings Bhd	61	Nestle (Malaysia) Bhd
12	British American Tobacco (M)	62	Oriental Holdings Bhd
13	Cahya Mata Sarawak Bhd	63	Pan Malaysia Corporation Bhd
14	Camerlin Group Bhd	64	Pan Malaysian Industries Bhd
15	Carlsberg Brewery Malaysia Bhd	65	Panasonic Manufacturing Malaysia Bhd
16	Chemical Co of Malaysia Bhd	66	Petaling Tin Bhd
17	Country Heights Holdings Bhd	67	Petronas Dagangan Bhd
18	Dialog Group Bhd	68	Petronas Gas Bhd
19	DIGI.Com Bhd	69	PPB Group Bhd
20	DRB-Hicom Bhd	70	PPB Oil Palms Bhd
21	Esso Malaysia Bhd	71	PSC Industries Bhd
22	Fraser & Neave Holdings Bhd	72	Puncak Niaga Holdings Bhd
23	Gamuda Bhd	73	Ramatex Bhd
24	Genting Bhd	74	RB Land Holdings Bhd
25	Globetronics Technology Bhd	75	Resorts World Bhd
26	Golden Hope Plantations Bhd	76	Road Builder (M) Hldgs Bhd
27	Guinness Anchor Bhd	77	Shell Refining Co (FOM) Bhd
28	Hap Seng Consolidated Bhd	78	Sime UEP Properties Bhd
29	Hume Industries (Malaysia) Bhd	79	Star Publications
30	IGB Corporation Bhd	80	Sunway Holdings Incorp Bhd
31	IJM Corporation Bhd	81	TA Ann Holdings Bhd
32	KFC Holdings (Malaysia) Bhd	82	TA Enterprise Bhd
33	Kian Joo Can Factory Bhd	83	Talam Corporation Bhd
34	KSL Holdings Bhd	84	Tan Chong Motor Holdings Bhd
35	Kuala Lumpur Kepong Bhd	85	Tanjong Public Limited Company
36	KUB Malaysia Bhd	86	TH Group Bhd
37	Kulim (Malaysia) Bhd	87	Tradewinds (M) BHD
38	Kumpulan Guthrie Bhd	88	Time Dot Com Berhad
39	IOI Corporation Bhd	89	Time Engineering Bhd
40	IOI Properties Bhd	90	Top Glove Corporation Bhd
41	Island & Peninsular Bhd	91	Transmile Group Bhd
42	Jaya Tiasa Holdings Bhd	92	UBG Bhd
43	JT International Bhd	93	Uchi Technologies Bhd
44	K & N Kenanga Holdings Bhd	94	UMW Holdings Bhd
45	Kwantas Corporation Bhd	95	Unisem (M) Bhd
46	Lingkaran Transkota Hldgs Bhd	96	WCT Engineering Bhd
47	Lingui Developments Bhd	97	WTK Holidings Berhad
48	Lion Corporation Bhd	98	YTL Cement Bhd
49	Magnum Corporation Bhd	99	YTL Corporation Bhd
50	Malakoff Bhd	100	YTL Power International Bhd

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Green Road Approach in Rural Road Construction for the Sustainable Development of Nepal

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Abstract

Transport infrastructure provides a basis for economic activities in the rural areas in the long term. But the environment consequences cannot be neglected only foreseeing long term economic benefit. Difficult topography and unstable geology make the road construction difficult in the rural hills of Nepal. Beside, the predominantly absolute poverty in the region realizes the essence of the appropriate approach in the rural road construction. With its approach of constructing rural roads considering environment and rural poverty alleviation measures, Green road approach is proving to be a sustainable way of constructing rural roads. Environment friendly construction techniques, participatory and decentralization approach, optimum utilization of local resources, simple technology, local capacity building and self help efforts justified Green road approach as a best way of constructing rural roads in hill districts of Nepal. The study analyze the different aspects of green roads in Nepal on the basis of the basic themes define in the dictionary of the sustainable development.

Keywords: Sustainable, Environment, Participatory, Green roads, Poverty alleviation

1. Introduction

Nepal is a predominantly a mountainous country with about 77% of its area lie in the hill and mountain regions. The country is approximately rectangular in shape having an area of 147,181 square kilometers. The north-south length is up to 200km and the east-west length up to 800km long. It has the greatest variation in altitude on earth which ranges from 60m to 8848m a.s.l. The country consists of the snow and ice covered Himalaya in the north. The southern plain is about 30km wide and the altitude ranges from 75m to 280m high with fertile lowland (also swampy) which is known as Terai. The country has a great diversity in climate, vegetation, culture and religion.

According to the United Nation, Nepal counts to the 'Least Developed Countries" and to the "Most Seriously Affected Countries" The country economy grow merely 2% in FY 2004/05. Within the region of South-Asia Nepal's income is low and remains dependent on the agricultural sector, providing employment for 80 % of the population. Poverty is deep and pervasive in Nepal, with wide disparity across regions. According to the 1995–1996 Nepal Living Standards Survey (NLSS), 45% of Nepali households are poor. Poverty is predominantly rural; rural poverty rates of 47% are more than twice those of urban areas (18%), and more than 90% of the poor live in rural areas. On the disparity basis of ecological region, the poverty incidence goes significantly from terai (37%) to hill (50%) to the mountain region (63%). However, the latest estimate for 2001/2 by the National Planning Commission "based on economic growth, population growth and the estimate of Gini index in the last few years" indicates a decrease of poverty incidence to 38%. However, the absolute number of people below poverty line has increased from about 4 million in 1976/77 to around 8.8 million in 2001/2.

According to the data of Department of Roads, up to March 2005 Nepal has 17,217 kilometers of road. Of these 4871 kilometers are black topped, 7403 kilometers are graveled and 7643 kilometers are fair weathered road. Up to that period only 60 districts headquarter out of the 75 have the access to the road facility. So, the country has a road density of about 12 kilometers per 100 square kilometers. Tenth plan target of accessing 70 district headquarter does not seems to be meet under the present condition. Road or transport infrastructure is the major indicator of economic growth. Research has show that several important indicators of economy like trade, electricity, communication, health are positive correlated with the road infrastructure. So, it is a today's essence to invest in road infrastructure for future prospects of the country with the best possible way.

2. Problem and issues of rural road construction in Nepal

There are still fifteen districts in the country which are not connected to the national road networks. All the fifteen districts which are not connected to the National Road network are lies in the hilly and mountain region. The Himalayas constitute one of the most tectonically active fold mountain belts and experience some of the highest rates of erosion in the world. The difficulties presented by conditions of adverse geology, topography and land use are made more accurate in the humid sub tropical and humid warm temperature zones where rapid rock weathering and heavy rainfall act to induce land sliding and erosion. So the construction needs a proper consideration of the geology of the country. With that physical structures and topography, transport infrastructure development is considerably difficult in the country. The geology of the Nepal is weak and in the phase of stabilization. Even a small wrong development can cause the destabilization of the natural environment. Especially in the context of mega projects with the wider catchments can cause a lot of problems, social economical and environmental. In the past, plans were formulated aimed at increasing production of economic value and environment was not incorporated in the planning and implementation of the development activities. The development activities with potential of economic benefit were liable to carried serious risk of environmental adversities. Environment considerations were undermined because it was considered constraints to development. But the result of past negligence of environment is seen today. Losses of land, siltation, landslides, soil erosion, and loss of biodiversity are some of the adverse consequences. In the context of Nepal, lots of environment problems can be cited out that emerged out of developing transport infrastructures by neglecting the environment. Like, Landslide of Krishna Bhir located in the Prithvi highway is well known to all of Nepali and popular among international community, which is a result of defective construction methods and overlook of the environment. Department of Roads had spent a significant budget to control landslide of Krishna Bhir which is really a costly approach for a Least Developed Country like Nepal.

The conventional approach of developing transport infrastructure least considered the environment, Excessive use of blasting results the wider mass movement and slope instability. Construction methodology is costly and the works are carried through the contractors in the conventional approach and thus least considered the social aspects like poverty alleviation. So, with due consideration to difficult topography and wide pervasive poverty, it is very much essential to adopt a sustainable approach in developing transport infrastructure in rural areas.

So, the sustainability of infrastructure development is an issue of growing concern and calls for close examination of the design, construction and maintenance of road infrastructure. In developing countries, particularly in least developed countries (LDCs) like Nepal, the technical knowledge for infrastructure development in rural mountainous regions is still limited, which results in technical shortcomings and significant environmental impact. In the context of Nepal, the development of infrastructure is characterized by high initial costs, frequent damages due to harsh terrain and/or heavy monsoon rain, long construction time and low economic returns. Therefore, there is an urgent need for serious rethinking about infrastructure development strategies and practices. Decades of experience of infrastructure development in the mountainous region has amply created awareness among engineers and planners that development of infrastructure in mountainous regions requires a multidisciplinary approach which considered social, gender equity issues, economic, engineering, environmental and bio-technical factors for the sustainable economic development.

The study critically examines the road construction using Green road approach in the rural part of Nepal. The objective of the study is to relate the different principles and methodology adopted by road construction using Green road approach with the universally accepted themes of sustainable development.

3. Sustainable approach in road construction

The traditional or conventional development focused only on the final product. The method exploited the nature and the people. The wider exploitation of the nature leads to the environmental problems, land degradation and the climatic changes. Likewise it has generated the wider disparity between the haves and haves not that have created the hierarchies of people, gender and culture. Figure 1 address the need of sustainable development approach of doing any works. The sustainable development model addresses all the issues which are not addressed by the conventional form of development. Poverty alleviation measures, consideration of basic needs of people. Productive employment, environmental consideration, appropriate technology are some of the paradigm considered by the sustainable development models which contributed in reducing the gap between the haves and haves not.

World commission on environment and development (WCED) in 1987 define Sustainable development as "a development, which meets the needs of the present without compromising the ability of future generation to meet their own needs." In general, Sustainable development comprises of the three broad pillars social, environmental, and economic accountability, often known as the 'triple bottom line' these themes/pillars are also shown in Figure2.

The Agenda 21, Rio Conference on the Sustainable development 1992 identified the environment, social development and the economic development as the cornerstones of the sustainable development. The conference emphasized on the need to integrate and balance between the three cornerstones (Figure 3). The UK Government Uses the Sustainable

Development Commission which evaluates the sustainable development based on 15 different sustainable development indicators they are economic output; investment; employment; poverty and social exclusion; education; health; housing; crime; climate change; air quality; road traffic; river water quality; wildlife; land use; waste.

Conventional approach of the road construction doesn't satisfy the issues under the different themes of the sustainable development. The conventional road construction approach doesn't consider social inclusion of the people. Sustainable approach should be one which considered the wider socio-economic condition of the place where infrastructure is developed. Sustainable road project is the one which aim to reduce the rural poverty in the rural areas by extending the network of rural transport infrastructure and more importantly provide the employment to the community, empowering them, increase the institutional capacity building and improve the sense of accountability and transparency. The sustainable approach is the one which move a step forward beyond developing only basic infrastructure. It is essential to adopt the appropriate technology based on the need of people and stage of development.

3.1 Emergence of green road approach

The construction of low cost and low volume rural road with participatory and labor based approach was started in Palpa district of Nepal with the technical and financial assistance of Swiss Agency for Development and Cooperation (SDC) and German Technical Cooperation (GTZ). The approach includes community participation, financing, technical support, management and provision for the operation and maintenance of the completed road. All of these are integrated to form a new road construction and management approach that was given a name of Green Road Concept (GRC). The concept focus on conserving the delicate mountain ecology, in particular the protection of vegetation cover as means of soil conservation but also brings benefit to the local peoples by providing the off-farm employment opportunities during construction. The concept principles, a design approach and implementation procedure of the green road concept is best adaptable to rural road construction in Nepal. Simple technologies, use of local resources, participatory approach from planning to implementation, proper technical supports, and environment consideration are the important principles of Green road concept. The concept is also used as the labor based, environmental friendly and participatory (LEP) approach in the ADB and SDC funded rural road projects and RAP approach in the DFID funded roads, RAIDP approach in World Bank funded projects. Many road projects are formulated with the same approach till date. While for some the name may be different but the concept and principles are similar. Some of the major international funded rural road programs in Nepal which follow the principles similar to the green road approach are listed in the Table 1.

4. Why Green road approach "a sustainable approach"

It is the matter of the debate and discussion to define whether the Green roads approach as a sustainable approach in the context of Nepal. It had been a long time that the approach was started in Nepal. However, in this study I have tried to indicate some of aspects of green roads on the basis of themes of the sustainable development and internationally accepted sustainable development indicators to define green road as a sustainable approach for the Least Developed Landlocked country like Nepal. The principles, implementing procedures, outputs of the green road projects are the important verifiable indicators.

4.1 Environment Sustainability

One of the important aspects of the Sustainability is the protection of the environment. GRC is based on the environmental friendly approach. The Figure 4 listed the major environmental friendly indicators of green roads which prove the approach environmentally sustainable.

4.1.1 Minimization of slope cutting and preservation of the vegetative cover

The conventional road construction practice of developing the road width by full cutting and throwing the excavated material downhill is a wastage of valuable mass and can cause a damage to the vegetative cover. Instead a proper cut and mill method of mass balancing is used in the green road approach, the excavated materials are used for fill on the valley side by constructing toe wall (Figure 5). Similarly, the trees along the alignment are not cut till the road is operation. Suitable plants are collected and assessed for the bioengineering purpose. The roads under RIDP promoted the planting of soil-stabilizing plants such as bamboo along the sides of the project roads. These crops have helped stabilize the slopes along the road. Besides, once they grow up the local people can cut these bamboos to generate an economic income out of it. They can be used for the construction of the local houses and animal huts. (ADB, 2006)

4.1.2 Mass balancing

The conventional method of road construction by the use of the bulldozer and other heavy equipments ignores the mass balancing approach hence increases the significant height of the cutting which leads to the instability in the hill slope. The cut and throw by the conventional methods have the major environmental impact of loss of the agricultural and forest land. The excavated mass thrown downhill damages the agricultural land and covers the vegetation. In the mass balancing method, cut slope height becomes as smaller as half compared to the cut and throw approach, thereby making the cut slope much more stable and safe (Figure 6). Mass management should be considered in three dimensions, which

means mass management can be maintained not only in a single section but also in three dimensions. Box cutting should be avoided as much as possible. It can be avoided or at least minimized by shifting the centerline to the extent of the allowable horizontal curve radius. Excavated stone blocks, for instance, are stockpiled at the time of collection and re-used for constructing stone structures such as dry stone walls in the later phase. If these stones are rolled down the hill at the time of excavation, existing natural resources are wasted. Later, at the time of need, significant amount of financial resources is required to procure the same, which was once wasted

Deoja (1994) estimates that 400-700 cubic meters of landslides occurs per kilometer per year along the mountain roads and 3000 to 9000 cubic meters of landslide occurs per kilometer during the construction of mountain roads in Nepal. The study carried out among about 7900 cross section of 286 km of 18 hill roads of different regions by (Phuyal et al., 2008) found that while adopting mass balancing approach in green roads (GRs), from 3345 cubic meters to 2900 cubic meters can be managed in side slope filling and only about 465 cubic meters of the soil will be in excess per kilometer which is easily manageable along road to improve longitudinal gradient. The study concluded that about 6320 Sqm of excess virgin land per km will be cut if the conventional cut and throw is adopted.

4.1.3 Environment Friendly Construction methods

The construction of the green road considered environment in the best possible ways. Green road is constructed in phases with the objective of conserving the fragile mountain slope by minimizing the risk of landslide and soil erosion. Similarly, critical sections are identified and relevant adjustment is made. The phase wise construction (Table 2) help in assessing the local natural resources for utilization in construction phase. Construction material availability survey and Plant availability survey are done to assess the availability of local resources and plant respectively. Figure 7 shows a good representation of the phase wise construction of one of the road section of Hile-Bhojpur road.

Blasting which is frequently used in conventional approach is not allowed in Green road approach. Instead a simple method like Chiseling and Hammering, Heating and Breaking and Drilling is done to cut the rocks. The Local people employed during the construction works can easily use these simple tools and equipments. The approach did not use the dozers, excavators and other heavy equipments which consumes extensive amount of the fuels in the construction works hence there is no emission of the green house gases. The construction methods are environment friendly as it approach uses the labor intensive techniques that results almost zero carbon dioxide emission during the construction of the road

4.1.4 Proper water management

Water management is very much essential in the rural mountain roads. Green road approach adopts dispersed water management to avoid concentration of water along the road surface. Natural slope is used to disperse water towards the valley in a controlled manner Mountainside drains are generally only provided at the sections like steep road sections and hairpin bends. The road surface is generally provided with a 5% outward slope so that the surface runoff flows out of the road surface downhill. Diagonal surface drains are provided at the certain interval.

4.1.5 Environment appraisal

As mentioned earlier, careless planning and rapid engineering leads to the adverse environmental consequences in the form of slope stability, spoil disposal, water management and vegetation cover. GRC promotes the mitigation measures to reduce the negative environmental impacts. Use of substantial bioengineering measures, awareness raising among the communities of the consequences of environmental adversities are the part of the mitigation measures. More importantly environment appraisal has been an important part of Green roads. RAP projects use the standard procedures (Table 3) for the environmental appraisal before the implementation of any rural road projects.

Environmental Impact Assessment (EIA) study was performed to assess the likely impact on the environment and to offer recommendations to make the road environmentally and socially sound and sustainable. The EIA report is quite broad and covers various aspects of the physical, biological and socio-cultural-economic environments. It forms a legal obligation under the Environment Protection Act 1998. The EIA includes documentation of environmental baseline information of the project influence area, analysis of positive and negative impacts, recommendation of appropriate preventive and curative measures and environmental and social management plan to implement the mitigation measures.

4.1.6 Bioengineering

Bioengineering is the use of the living plants to reduce slope instability and soil erosion. Green road approach incorporates bioengineering as one of the important tools of environment conservation. Bioengineering is used as a preventive measure rather than a curative one. Local people having their indigenous skill are encouraged for the plantation works and establish the nurseries by providing the appropriate technical advice and support.

A plant availability survey was conducted simultaneously with the road alignment survey in the beginning. The local communities and farmers and landowners in the road corridors were included in the bioengineering process, to make it effective and sustainable as well as income-generating. They were trained to collect Bioengineering plants from the

surrounding areas, which included locally preferred fodder and fruit species, to plant along the road corridors. Their indigenous skills and knowledge of locally available and useful plants was sought. For example, plants such as Amliso (for making brooms), Uttis, and bamboo have the potential to start local cottage industries for income generation. Plantation works were carried out during the monsoons, after the completion of third phase of road construction. The overseers and engineers were trained in bioengineering techniques and local communities were trained in making coir nets from coconut fibers, which were used to stabilize the soil on cut slopes. (DRSP, 2006). Figure 8 shows the one of the landslide prone slope which is stabilized by the use of the bioengineering.

4.2 Sustainable Communities

One of the important aspects of the Sustainability is the sustainable communities. The Figure 9 listed the major social inclusive indicators of green roads which prove the approach socially sustainable.

4.2.1 Poverty alleviation through income and employment generation

For a rural area of like Nepal where most of the people is poor, a project initiated with green road approach brings benefits to the poorest. If a road can be built in an hour through conventional approach using dozer and blasting, then a same road finishing can take 15 days for a local to built using Green road (GR) approach. To make a comparison, for the purchase price of one bulldozer it would be possible to use 120,000 person days in labor-based road construction using the green road approach (equivalent to approximately 200.km of 1.5m wide trail, or .4 - 5. km of full width earthen road). (RRF, 2004)But the most important is the consideration of the livelihood of those people who are poor. The Green road approach facilitates the feeling of the ownership by the local people which ultimately contributes in the sustainable maintenance of the roads. Furthermore, the opening of the road brings the poorest an access to the local markets in addition to the opening of markets for the local products.

The construction of road is carried out in the agricultural slack season through labor intensive techniques generating off farm employment. The high percentage of the money spent on the construction stays actually in the local economy. It is estimated that a labor input of 12,000 person days per kilometer is required to construct a green road and payment to labor accounts for about 65 percent of the total cost per kilometer. (Sharma and Maskay, 1999). Likewise the project completion data of RIDP shows that 183,789 people were directly benefited through the improved access to the road network and other support services like access to hospitals (for child delivery, treatment following accidents, and other emergency situations) is faster and easier. The cost of transportation has been reduced by as much as 75%, and travel time to markets and services has decreased by up to 50%. Likewise, project generated unskilled and skilled employment for local poor people (about 4.2 million person days). New economic activities on the road corridors was emerged like emergence of new buildings and the development of enterprises as tea and snacks stalls, automobile repair shops, and other retail shops. Longer-term off-farm employment opportunities for local people were created, including maintaining existing roads, building new roads, driving vehicles, and working in automobile workshops. In Baglung, for example, the number of automobile workshops increased from two in 2001 to six in 2006. With the completion of the Baglung–Burtibang road, 7 dealers and 20 retailers have started supplying cooking gas. In the first 8 months of road usage, about 150 cylinders per month were sold. The forward and backward linkages of these activities have created jobs in and around the project areas and improved the quality of life of the project beneficiaries. About 67% of the project investment remained within the local economy. (ADB, 2006)

The first Phase of RCIW directly assisted about 250,000 poor and food deficit families (1.0 million people) to create productive assets and improve their self-help capacity. RCIW enabled the poor to Food for Work. (RCIW, 2001). Likewise, Rural Access Programme have estimates about 65% of the RAP road construction projects will be paid as wages to the poorer people, giving immediate benefits to a significant number of households.(RAP, 2003c) Till the July 2008 RAP have generated the employment of 1.61 million persons per day injecting 314 million in to the local economy. More than 8500 households are directly working as the road building groups along the RAP road zone. (MLD, 2008). Likewise DRSP phase II generated 1.2 million person days of the employment out of which significant number are from the disadvantage and vulnerable groups.

4.2.2 Decentralization and participatory approach

The approach adopts the decentralization strategy throughout the process of project cycle. The Green road approach uses a participatory involvement of local authorities and stakeholder communities throughout the formulation, planning, construction and maintenance phases to promote a sense of local road ownership for its operation and maintenance. The beneficiaries make the decisions on the selection of the project, road alignment, labor management, User group formation, and resource distribution and utilization.

Political consensus is developed with involvement of all stakeholders like DDC, VDC, political parties to prepare the District Transport Master Plan. The plan worked as the basis for prioritizing the demand of rural roads in the district. Thus this ensures the infrastructure development does not go in an independent direction and incorporated with the national plan. The participation of the community at each stage is fundamental to the green road approach. After the

master plan is formalized the next level of participatory consultation begins at the micro levels. Different Road management committees with different levels are formed. These committees formulate management policy and assign responsibilities to the different User groups. User groups that comprise of 10 to 15 workers are assigned the construction works. The committees facilitate the construction works along with resolving the local disputes. Since, the works is carried through the community participation, social mobilization support is important part of the approach. Usually NGO are assigned for a social mobilization task. They encourage local people on the active participation in the construction and help them to create sense a local ownership.

4.2.3 Local level capacity building

Local level skill development is one the integral part of Green roads. Local NGOs are assigned for the social mobilization support to develop the sense of ownership and involvement. Beside they promotes self help activities like group savings and credit operations, promotion of nontraditional farming practices, promotion of off-farm income opportunities. Various levels of training are provided during the construction process and trained local people become a source of local manpower for neighboring road projects, and for later maintenance, rehabilitation, and upgrading works. Using collective financing from the central, district, and village governments and institutions creates the attitude that it is possible to build and maintain infrastructures with local resources and to generate a sense of local ownership. Public audits make people aware of how the funds are utilized by providing information on project plans, and expenditures. These public audits were an effective tool to improve transparency and accountability. DRSP Phase II (2002-2006) has achieved good results of the capacity building in the form of providing long term economic benefit to the locals. Twelve of the saving groups have been converted in to cooperatives, local NGOs are trained for social development, and Over 200 income generating groups are formed. So, these indicators show that livelihoods of the local people are improved through the social interventions (beyond the road). So, Local level capacity building can be defined as the part of the community development aims to extend the benefits to people working in the road by raising awareness to improve their standard of living providing opportunities to maintain income generating activities. In the 2000 fifth year of RCIW program (Phase I) 11,100 User Groups members are involved in capacity building training, likewise 17623 user group members received capacity building training in 2000/01, 32,142 User groups received training in Capacity building for the year FY 2002/03. These trainings found to fruitful as many groups like micro project groups, saving and credit groups are able to secure and upgrade themselves for sustainable livelihood even after the withdrawal of the project support. Likewise, RAP emphasized on the skill development of RBGs members in order to effectively utilize the credit taken from group fund. RBGs have identified the opportunity available for income generation at their village and acquiring required skills and knowledge through local resource persons (LRP). RAP has capacitated 99 such LRPs in identified income generating options. More than 60 percent of members got training on on-farm and off-farm IGA options and nearly 50 percent have already started meaningful income generating activities earning a total of NRs. 2.3 million from those activities. (MLD, 2008)

4.2.4 Social equality and gender balance

The 1996 NLSS shows that income poverty incidence is correlated with caste / ethnicity, education and land ownership. In general the occupational caste group (Kami, Damai, Sarki -- traditionally considered the 'untouchables') have significantly high poverty incidence compared to the 'higher caste' group. Household heads who are either illiterate or have only primary education have the highest incidence of poverty and those with above secondary education have the lowest incidence. Similarly incidence of poverty has, in general, an inverse relationship with amount of land holding. (Ojha, 2004). Social conflicts arise because of the social disparity. Advantage group have the competitive advantage in the form of knowledge and control of resources over the disadvantage group (DAG), ethnic minorities and indigenous populations because of education, access to infrastructure, access to knowledge and property. And because of that DAG group are the poorest among the communities. The Green road approach emphasizes on the good participation of the low caste and disadvantage group. The approach addresses the social inequalities that are the root cause of the conflict. DRSP project operated in six districts on Nepal support activities start with opportunities for the poor families to engage in the construction work to bring in good wage in timely manner. The level of participation of the DAG groups on all the six districts under the DRSP project stay at average 71%. (DRSP, 2006)

Likewise Gender equality is principle aspect of GRC to promote the women participation in all the intervention areas. The project provides the equal opportunities for men and women; improved the integration of women into the decision making process; and enhanced the gender sensitivity of stakeholders in intervention areas. The women are not confined within the boundary of the house they are actively participating in the construction work. (Figure 10)The women received the same wages for the similar types of and same quantity of the work as men. Under the RCIW Phase I, District gender action plan was developed and integrated in the RCIW work plan to create awareness among all RCIW decision-makers so that they are able to identify and help solve problems arising from gender inequality and discrimination. The action plan mandated to include 50% women in each User's committee. (RCIW, 2003).

4.3 Sustainable Economy

Another important aspect of the Sustainability is the sustainable economy. The Figure 11 listed the major economy indicators of green roads which prove the green road approach economically sustainable.

4.3.1 Sustainable economic development

Creation of the employment opportunities have been the major objective of the development planning in recent days. GRC not only bring the off farm employment to the large number of the people but the mechanism development within the GRC projects contributing in the country economic growth. The mechanism promotes the local towards savings which provides them to involve in the enterprises and income development activities. The savings made by them provide the basis for the further investment, so GRC promotes the sustainable economic cycle (Figure 12). In the Hile-Bhojpur road constructed under the support of the RAP, Road building groups (RBGs) were encouraged to save a minimum of 10% to 20% of their earnings on the voluntary basis. RBGs are responsible for the preparation of group rules and regulations. The rules and regulations will cover the criteria for prioritization of borrowers, amount and range of loans, etc. Loan disbursements are mainly for cattle rearing, poultry, goat keeping, pigering, loan for domestic expenses and treatment of family members. Some borrowers have used the funds to start small grocery shops, set up trading activities, farm fish, and start up businesses such as tailoring, etc. (Dhaka IS, 2008) Figure 13 shows the different enterprise development activities performed by the locals through the group savings in the Hile-Bhojpur road. Beside these core benefits, GRC also generated the different quantifiable like transport cost savings, producer surplus benefits, appreciation of land values similarly non quantifiable benefits like faster and easier access to market, faster and easier excess to public services and access provision for other rural infrastructures that can be generated through the normal road project. *(BN Acharya et al., 1999)*

A rapid industrialization is not possible in the country like Nepal where large proportion of the development budgets still dependent on the donor countries. Several studies have shown that road infrastructure is positively correlated with the economic development. Easy access to markets, get rid from the physical isolation and better access to other complimentary infrastructure like health, education, communication is vastly possible after the development of the roads. Lamosangu-Jiri road which has been considered as the first green road constructed is an example. This road has brought long-term development such as tourism, better schooling, and improved health care to the area. In the district of Dolakha where this road was built, the literacy rate has jumped three-fold, i.e., from 17% in 1981 to 51% in 2001. Similarly, while the infant mortality rate in the district in 1989 was 108 for every 1000 births, it has now declined to 50 per 1000 births. The maternal mortality rate for every 100,000 also declined from more than 600 to 350 during the 1990s. Though all this improvement cannot be attributed to the Lamosangu-Jiri road alone, it is evident that the facilities the new road offered to the people has played a crucial role in this development. (SDC, 2008). However, from the experience of other countries, integrated model of investment in roads alongside the education and agriculture (Nepal is predominantly agriculture based economy) will be more effective to rapidity the economic development. Green roads are said to be economically viable if the internal rate of return is at least 12%. *(BN Acharya et al., 1999)*. The overall economic internal rate of return (EIRR) over the 20 year economic life of the project on the basis of cost and benefit streams for the RIDP Project is estimated to be about 20%, against the appraisal estimate of 13% that was made on the 1997. (ADB, 2006)

4.3.2 Optimum utilization of local resources

Optimum utilization of local resources is one of the important indicators of the sustainable development. Green road concept encourages the optimum uses of the local resources in the form of the local labor, local materials and local finance. Suitable construction techniques (such as soft structures, etc.) are applied by using mainly local construction materials (excavated stone, chips, soil, plants, etc.) and locally produced tools and low-cost intermediate equipment where possible (i.e. suitable wheelbarrows and appropriate drilling equipment, etc.). Since off-farm employment opportunities are very rare in the rural areas, labor-intensive road construction methods (mainly manual work) are adopted rather than capital-intensive technologies (such as bulldozers) to generate local employment opportunities and to recycle financial resources at local level as “poverty alleviation” measure. A re-utilization of locally available natural resources obtained from excavation is strongly utilized in the construction process. This form of re-utilization of material is economic and environment-friendly. Excavated soil, rocks, and topsoil and vegetation are the primary construction materials for Green Roads. Excavated soil can be used in the filling works for mass balancing as well as for widening the roads at the passing bays and switch backs. Likewise the stone obtained during the construction works are stacked along the road so that they can be re used for the construction of dry stone masonry, gabion walls and water management structure. Vegetation and top soil can be used for turf and re-vegetation of the hill slopes. Local indigenous skill and knowledge are optimally utilized which makes the road construction not only cheaper but also maintainable. Flexible structures like dry stone and gabions are preferred over the masonry or concrete structures to utilize the local materials, skills and to promote the local workmanship.

4.3.3 Foreign Exchange Control

Steel, Cement, fuels, heavy equipment and machinery are the part of the industrial goods which needs to be imported for the construction works. Like in many hydropower projects, large numbers of the capital goods are imported in the form of turbine, equipment set up and others. Hence, high percentage of the money attributed by the international agencies (either loan or grant) return immediately back into the industrial world. Road construction using GRC rely on the optimal utilization of the local resources hence it contribute in the maintaining the foreign exchange reserve of the country.

4.3.4 Cost reduction

Heavy equipment is expensive to mobilize, difficult to deploy in site without excessive environmental damage and subject to excessive downtime due to the delay in obtaining spares and fuel from the capital. From the experience of the Department of Roads in Nepal, it was estimated that per km cost of construction of road by conventional method as NRs 5 to 8 million in 1998 which is expected to increase almost twice to date considering heavy price rises in the fuel, construction equipments and the construction materials .Earlier, Based on the series of the cost analysis mainly of the Palpa and Dhading Roads in 1985 per km cost was estimated as NRs 1.2 million/km which is equivalent to the 12000 labour/days. The Swiss constructed the Lamosangu-Jiri road at the cost of NRs 250 million for the entire 110km stretch in 1985; the road has been serving as a model for other mountain roads even after more than 20 year of its construction. (Shrestha, 2006)

The cost expenditure under the DRSP phase II (Table 4) shows the similar results, 18km new construction roads made in Okhaldhunga District under DRSP phase II cost around NRs 2.77 million per km. So, Cost does reduced if the road are constructed using the green road concept and the most importantly over 65% of the cost remains within the local economy, which in case of the dozer made construction will goes to the capital motivated Contractors. Generally, Green road projects adopt the cost cutting measures. The implementation of these projects minimizes the use of expensive items. Cost-cutting measures include using locally available workers and materials instead of bringing in technicians and construction materials such as cement and steel. This approach ensures projects are affordable and built within the financial limitations of local communities.

4.3.5 Sustainable maintenance

Road assets are the major assets and to conserve them maintenance is essential. Delayed maintenance works results the value of road in loss. The study has show that Nepal is losing the value of $ 1 to 2 billion due to the lack of proper maintenance work in overall road network. The approach works to develop a maintenance culture and system within the proximate area to provide the sustainability of the infrastructure and also the long term employment for a proportion of the Road building groups. The principle behind the sustainable maintenance of the road constructed under GRC is the feeling of the ownership. Green Road Concept emphasizes road maintenance as the responsibility of the road owner. Roads are closed during the monsoon to prevent excessive vehicular destruction of the surface (e.g., formation of deep rills). Road Maintenance initiative was taken in 1989 in Palpa District and Dhading in 1993 and introduced the system of toll tax collection and routine maintenance. Length workers usually the locals from the nearby road corridors were employed for the routine road maintenance works.

5. Conclusion

Sustainable way is the best way of doing anything. Green road approach is a sustainable way of constructing the rural roads in the Nepal. The green road approach considered both environments, social and economic issues of the country. The GRs adopt the mass balancing as the environment friendly approach and more importantly it utilizes the various soil bioengineering techniques to ensure stability of slope and control of the erosion. GRs promote the optimum utilization of local construction materials, equipments and local people participation in each stage of the project. The data show that GRs can be constructed in relatively low investment cost and more than 65% of the total construction cost stay within the local economy. The GRs ensure the decentralized approach through the participation of the local stakeholders and communities throughout the project life cycle from planning to the implementation. The GRs approach strongly addresses the social inequalities and disparity within the society. It adopts the poverty alleviation measures through the employment generation during construction to the income generating activities through the self help promotion or local level capacity building. It encourages the local to take the ownership of the road for the sustainable maintenance of the roads. Green roads fully satisfied different sustainable development indicators defined under the three themes i.e. social, economic and environment of the sustainable development in the context of Nepal. So, if there is a situation of choosing a hare or tortoise for sustainability. Answer definitely will be tortoise with a sustain future a head at least for next 10 years. So the Green road approach is the best sustainable way of developing rural road infrastructures in rural Nepal.

References

Books, Reports

ADB. (2006). *ADB Completion Report, Rural Infrastructure Development Project, Manila, 2006.*

District Roads Support Programme. (DRSP, 2006). *2002-2006 Phase II Report*, Program Support Unit, SDC, Kathmandu.

B N Acharya, R Aryal, B Karmacharya, W. P Meyer. (1999). *Green Roads in Nepal*, GTZ, SDC, Kathmandu..

Klatzel Frances. (2000). Green *Roads: Building environmentally friendly, low maintenance rural roads through local participation***,** Best Practice report, spring, GTZ, Kathmandu.

Ministry of Finance. (2008). *Economic Survey*, July, Kathmandu.

Ministry of Local Development. (MLD, 2008). *Key Achievement of 2007*, March, Kathmandu, Nepal

National Planning Commission. (2003). *Tenth Plan (Poverty Reduction Strategy Paper 2002-2007)*, May, Kathmandu.

Ojha Durga P. (2004). *Inventory of Poverty and Impact Monitoring (PIM) Approaches in Nepal,* Poverty Monitoring Unit, GTZ, Kathmandu Nepal.

RRF, Nepal. (2004). *Labor-based Green road construction in Nepal, a briefing paper,* Rural Road Forum, Kathmandu.

RAP. (2003a). *Implementing the Rural Access Programme Nepal Fact Sheet Environment*. March 2003, Kathmandu, Nepal

RAP. (2003b). *Implementing the Rural Access Programme Nepal Fact Sheet Livelihoods and Enterprise Development*. May 2003, Kathmandu, Nepal

RAP. (2003c). *Implementing the Rural Access Programme Nepal Fact Sheet Physical Access Infrastructure* May 2003, Kathmandu, Nepal

RCIW. (2003). *Annual Reports 2002/03*, Rural Community Infrastructure Works, Kathmandu.

Swiss Agency for Development and Cooperation, SDC. (2008). *Asia brief, Nepal Roads to Prosperity Partnership results*, SDC, South Asia Division, Kathmandu.

TRL. (1997). *Overseas Road Note 16, Principles of low cost road engineering in mountainous regions with special reference to the Nepal Himalaya*. Berkshire, United Kingdom.

Papers/Articles from monographs, conference proceedings

Deoja, B.B. (1994). Sustainable approaches to the construction of roads and other infrastructure in the Hindu Kush-Himalayas, International Centre for Integrated Mountain Development (ICIMOD) Occasional paper, 24, Kathmandu, 70p.

Dhakal IS. (2007). *Empowering Rural poor through road construction: Experience from Hile Bhojpur feeder road project, Nepal,* A paper presented at 23rd congres mondial de route Paris, 2007.

Kohler Thomas, Hurni Hans, Wiesmann Urs, and Andreas Kläy. (2002). *Mountain Infrastructure: Access, Communication and Energy*, Thematic Paper, Center for Development and Environment, University of Berne, Bern, Switzerland.

Phuyal D, Stamper K and Acharya M S. (2008). *Green road approach: An appropriate method of hill road construction in Nepal for the preservation of mountain environment and landscape*, paper presented in the XIII International Interdisciplinary Conference on Unicity, Uniformity and Universality in the Identification of the Landscape and Cultural Mosaic, Aquileia-UD, September 2008.

Uprety BK. (2008). *Sustainable development*, A paper presented to the student of Nepal Engineering College, Kathmandu..

Papers/Articles from Journals and Newspapers

Mulmi Abhiman. (2007). *Sustainable development approach in the rural road construction, promotion of the green roads,* Nepal Technical Journal of Nepal Engineers' Association, January 2007, Volume I, 26th Executive Council, Kathmandu, Page 1-5.

Pantha Bhoj Raj. (2006). *Rural road design and construction: An overview of consideration of disaster management in green road in Nepal, http://www.nejas.org/* (February 2006).

Sharma Suresh and M.L Maskay. (1999). *Community Participation and Environmental Protection in the construction of Mountain roads: Promotion of the "Green road" approach in Nepal,* Transportation and Communication bulletin for Asia and Pacific, No. 69, Participatory approach to transport infrastructure development, United Nation, New York. Page 59-77.

Shrestha Pragya. (2006). *The great green road,* Nepali times weekly, July 2006, Page 5-6.

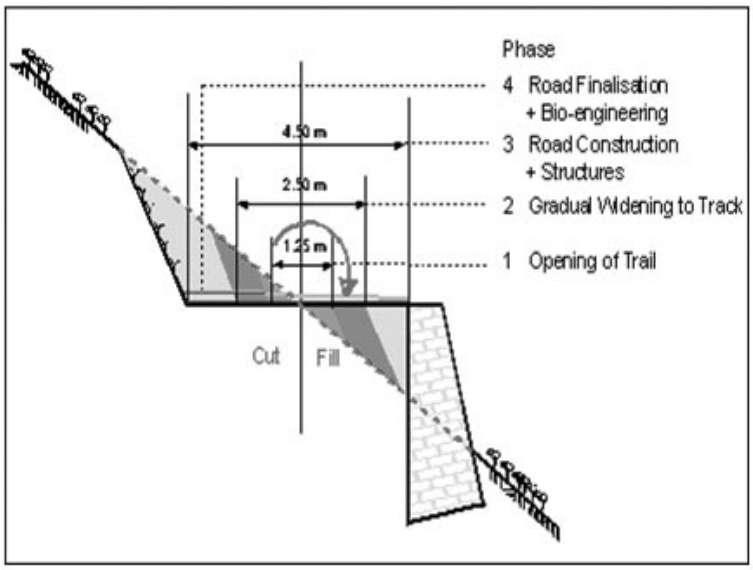
Table Legends

Table 1. List of the Major projects which follow the Green road approach or similar approaches

S.N	Major rural road project and duration	Funding agency	District covered	Project cost	Status
1	District Road Support Program (DRSP I) 1999-2002	SDC/GoN/DDC	3	NRs 95.2 million	Phase out
1	District Road Support Program (DRSP II) 2002-2006	SDC/GoN/DDC	6	NRs 395 million	Phase out
	District Road Support Program (DRSP III) 2006 to 2010	SDC/GoN/DDC	6	NRs 695 million	Running
2	Rural Infrastructure Development Program (RIDP) 1995-2005	ADB/GoN	3	NRs 1.24 billion	Phase out
3	Rural Access Program (RAP) 2001-2007	DFID/GoN	7	NRs 1.4 billion	Phase out
3	Rural Access Program (RAP) phase II 2008 – 2011	DFID/GoN	7	NRs 2.21 billion	Running
4	Decentralized Rural Infrastructure and Livelihood program (DRILP) 2005-2010	ADB/GoN	18	NRs 3.87 billion	Running
5	Rural Access Improvement and Decentralization Program (RAIDP) 2005-2010	WB/GoN	20	NRs 3.1 billion	Running
6	Rural community and Infrastructure Works (RCIW) 1996-2007	WFP/GTZ/GoN	30	NRs 3.37 billion	Phase out
7	Decentralized Finance and Development Program (DFDP) 2000-2007	UNCDP/DFID	20	NRs 320 million	Phase out

(Source: MLD, 2008)

Table 2. Phases of Green road construction

Phase 1	Opening of Trail	Average width up to 1.25m	
Phase 2	Gradual Widening to track	Average width up to 2.5m	
Phase 3	Road Construction	Full width with retaining and water management works.	
Phase 4	Finalization and bioengineering	Final shape of road, construction of passing bays.	

(Source: BN Acharya et al., 1999)

Table 3. Environmental appraisal procedures followed by RAP

Environmental activity	**Purpose**
District Environmental Brief	A profile of environmental conditions in each RAP district
Initial Environmental Examination	The first level of environmental study, required for all district roads and for other types of programme works such as major bridges
Environmental Impact Assessment	A full in depth study of potential impacts, carried out if an IEE finds that impacts might be significant. Also required for feeder roads.
Environmental Management Plans and Environment Monitoring	The process of making sure that the recommendation from environmental studies are applied in practice, both during the projects and afterwards.

(Source: RAP, 2003a)

Table 4. Actual cost expenditure under DRSP Phase II

District	**New construction (km)**	**Rehabilitation (km)**	**Routine and periodic maintenance (km)**	**Upgrading (km)**	**Cost (NRs/km)**
Okhaldhunga	18	NA	NA	NA	49,917,848
Sindhuli	32	20.5	58.5	16	53,271,618
Ramechhap	13.8	8.1	8.1	NA	61,482,652
Dolakha	8.5	44	51	16	50,257,786
Sindhupalchowk	13	66.9	76.9	10	50,094,537
Kavrepalanchowk	7.4	46.5	61.5	12.3	51,231,917
Total Km	92.7	186	256	54.3	31,825,639

(Source: DRSP, 2006)

Figure Legends

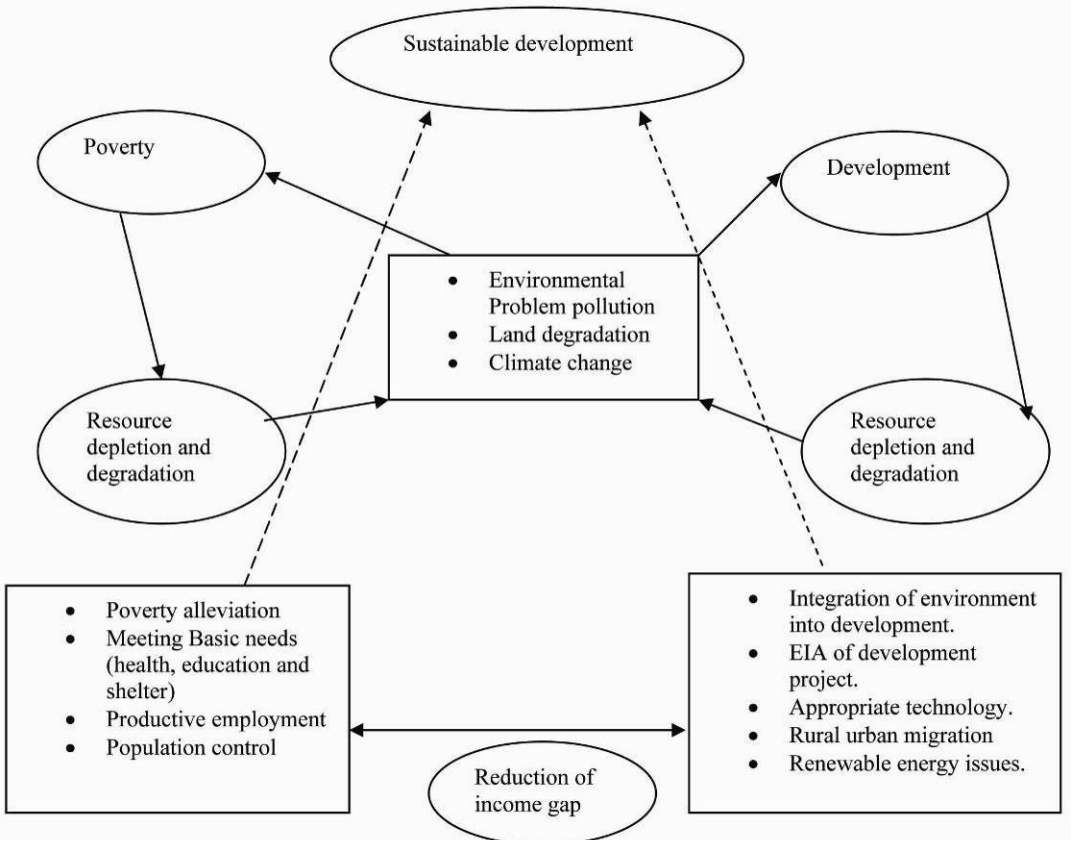


Figure 1. Need of sustainable development (Source: Uprety BK, 2008)

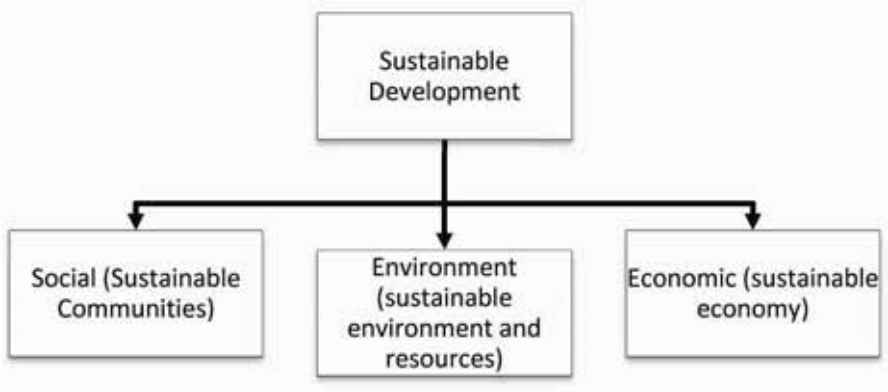


Figure 2. Pillars of sustainable development approach

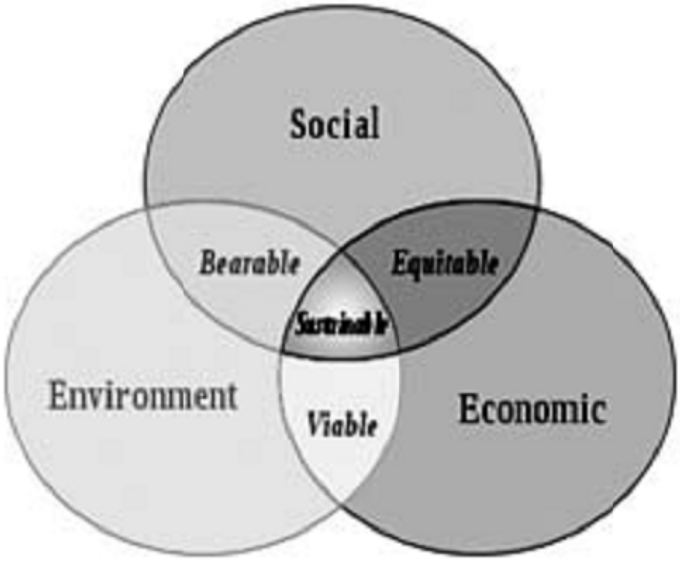


Figure 3. Interrelation between the 3 pillars of sustainable development, interdependent and mutually reinforcing (Source: Uprety BK, 2008)

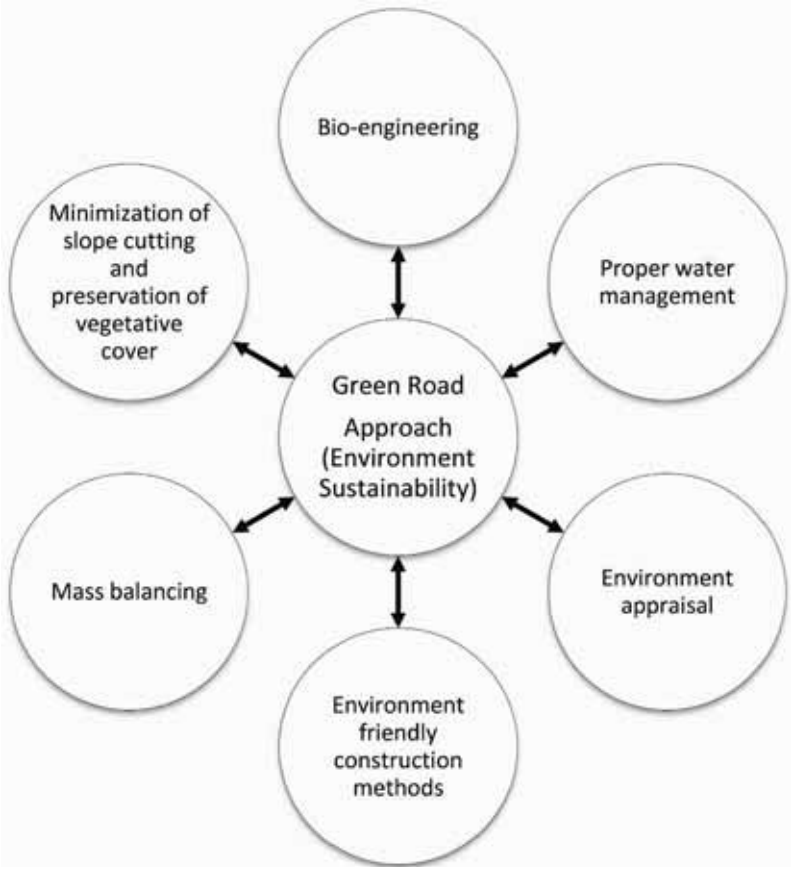
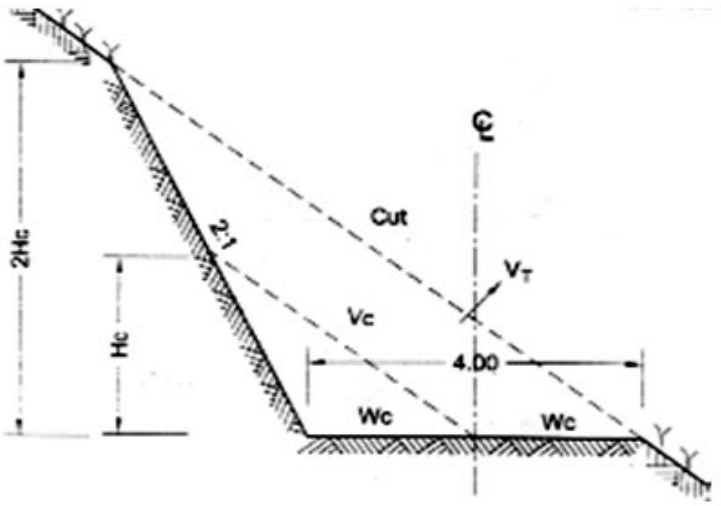


Figure 4. Green road approach for sustainable environment

Figure 5. Toe wall constructed for filling in the valley side



Legend
H: Height
W: Width
V: Volume
C: Cut
F: Fill

Figure 6. Mass Balancing (Source: BN Acharya et al; 1999 pp52)

Figure 7. Phase construction; first phase 2.5m track opening to gradual widening to 4.5m road length. (Source: Dhakal IS, 2007)

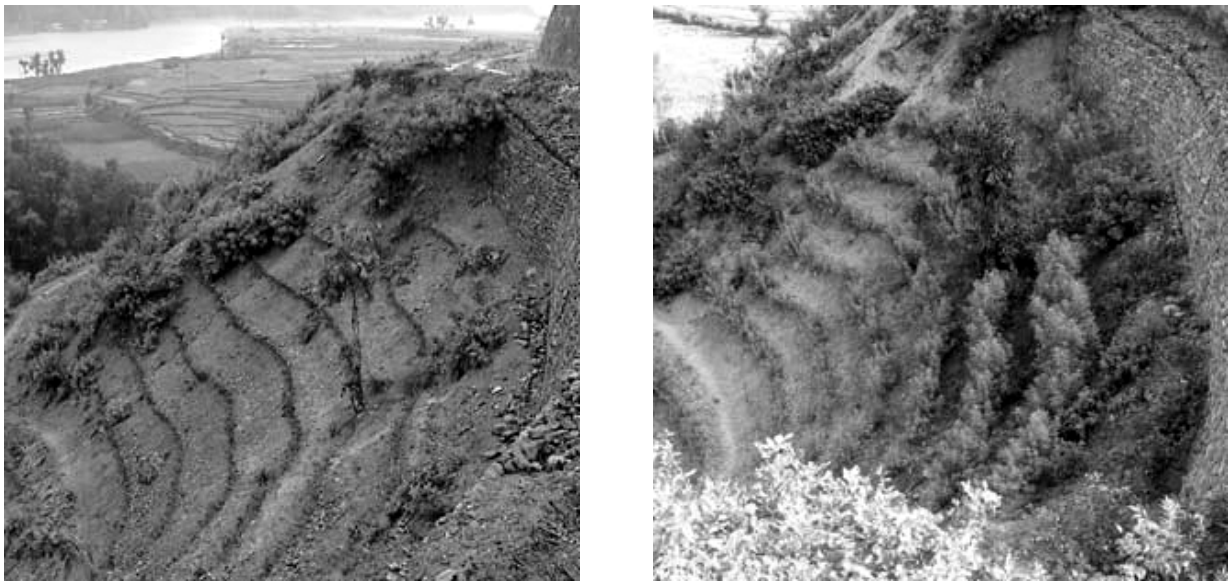


Figure 8. ensuring the slope stability after the bioengineering work downward the roadside.
(Source: DRSP, 2006)

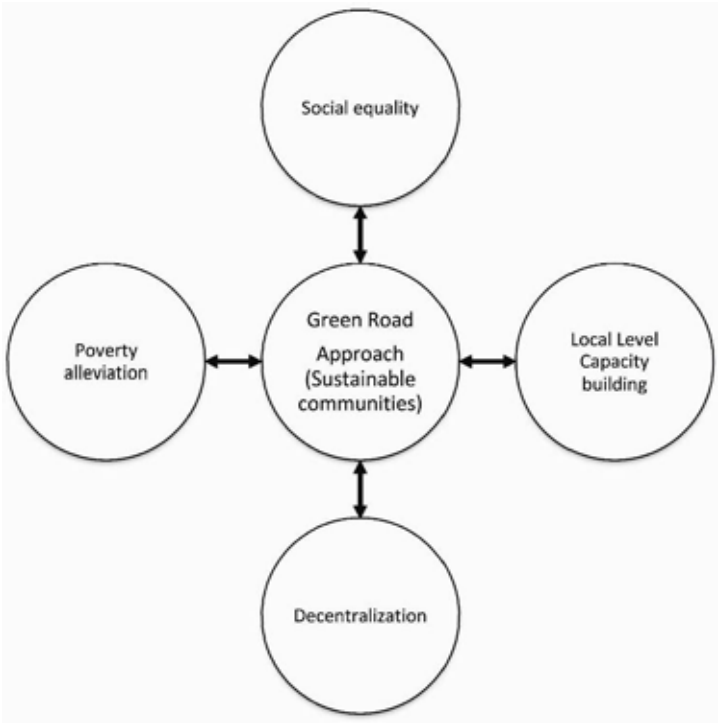


Figure 9. Green road approach for sustainable communities

Figure 10. Active participation of the women in construction work (Source: DRSP, 2006)

Figure 11. Green road approach for sustainable economy

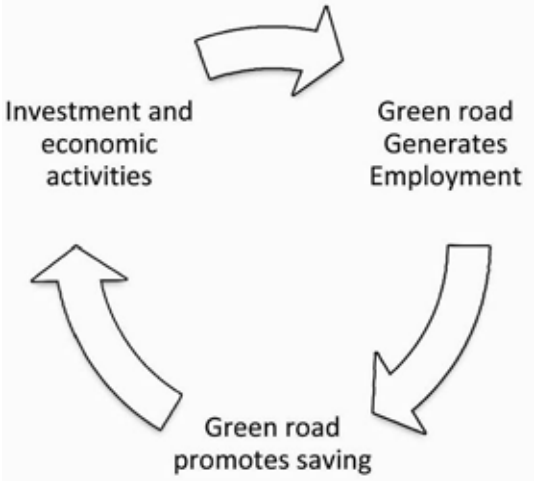


Figure 12. Green road economic cycle

Figure 13. Enterprise development activities through group savings delivering returns; in clockwise direction (a) Pigering, (b) Cash crops (c) shops (d) goat keeping (Source: Dhakal IS, 2007)

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Designing of Scenic Spots Trail from the Angle of Ecological Protection- A Case Study of Xixi National Wetland Park

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Abstract

Human being attain huge economic income resulting from tourism, meanwhile they paid an enormous cost for that. Environmental pollution and resource destruction in scenic spots become an important issue that tourism development is confronted with. Trail is an significant basic service facility in scenic spots, and its design is close correlated with project development and resource protection. In the present paper, we attempted to start with trail design in scenic spots, through expounding trail function, in a case study of Xixi national wetland park, make an empirical study, and put forward principles trail design should follow. We hoped that we could enhance environmental carrying capacity and promote sustainable development in scenic spots by proper trail design.

Keywords: Scenic spots, Trail design, Ecological protection, Xixi national wetland park

1. Introduction

Trail, as an significant basic service facility in scenic spots, is a cohesive tie connecting with various scenic spots, and plays a cardinal role in the tourism planning and construction(Zi, 1999, PP.58-60). On the one hand, trail planning and design is a re-integration for resources in scenic spots, and determines environment layout and project development. Its construction inevitably causes damages in some degree to resources in scenic spots; On the other hand, trail is a significant facility to guide and load tourists. Their most activities in scenic spots carry through the trail. Trail design determines the impacts of tourism action of tourists on scenic spots environment to some extent. Consequently, trail design affects tourism development to some extent in scenic spots. In the present paper, based on trail functional analysis in scenic spots, we studied trail design in scenic spots from the angle of ecological protection, in a case study of Xixi national wetland park, and put forward principles trail design should follow in the light of ecological protection, with an attempt to offer reference for trail planning and design in scenic spots.

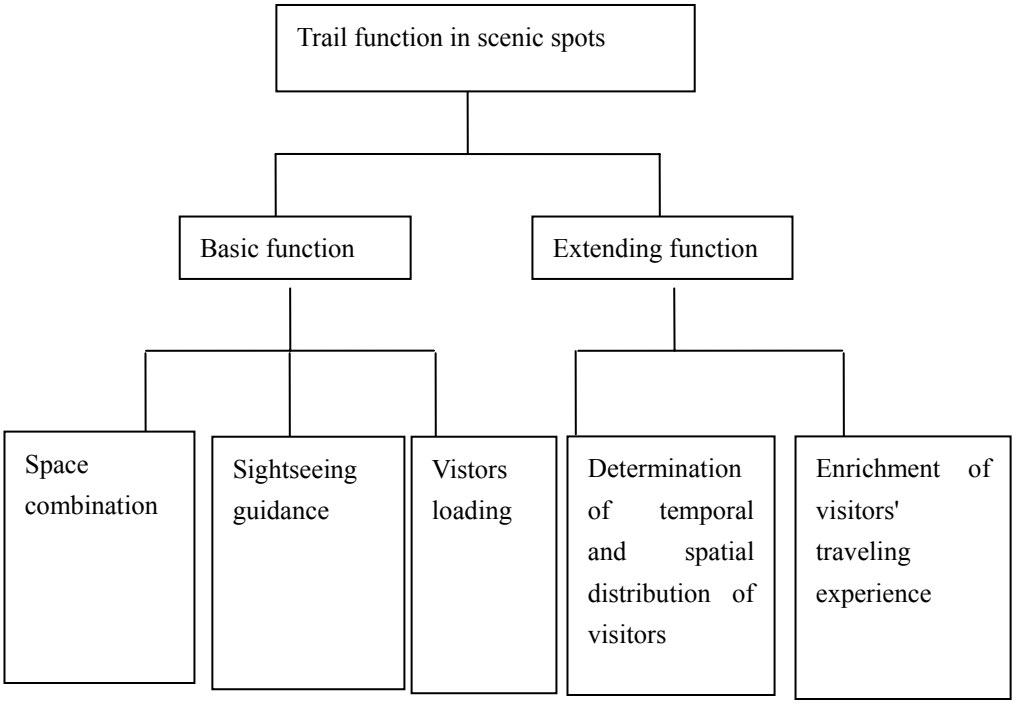
Research results about trail in China focused on pavement design in garden, forest park and mountain style scenic areas(Meng, 2008, P. 286; Wang, 2007, P. 146; Wang, 2007, PP. 492-564; Li, 2006, PP. 55-56; Yang, 2004, PP. 46-48; Wang, 2008, PP. 82-88.2-7), with an emphasis on the design of trail layout in scenic spots, as well as the construction standard studies of trail and its relevant facilities, etc. In the present paper, based on trail functional analysis in scenic spots, we studied trail design in scenic spots from the angle of ecological protection, in a case study of Xixi national wetland park, and put forward principles trail design should follow in the light of ecological protection, with an attempt to offer some references for trail planning and design in scenic spots.

2. Trail and its function in scenic spots

Through the observation of tourists action, considering from the angle of visitors characteristics and environmental protection in scenic spots, we classified trail function into two sorts, viz. basic function and extending function. Basic function includes the combination of scenic spots space, sightseeing guidance and visitors loading and so on; Extending function includes determination of temporal and spatial distribution of visitors, enrichment of visitors' travelling experience and so on. Therefore, trail is the combination and joint of resources in scenic spots, and a facility to guide and load tourists. Its design would affect the temporal and spatial distribution of visitors and the quality of traveling

experience.

Trail functional structure diagram in scenic spots:



2.1 Basic function

2.1.1 Determination of environment layout in scenic spots

One basic function of trail in scenic spots is to link the scattered spots, and its connection mode determines the whole environment layout of scenic spots. Meanwhile, trail is not only the tie of sight organization and relation, but also could give different visual and recreational experience due to its meandering and crankle or rising and falling(Li, 2003, PP. 10-11). Accordingly, trail itself is an important part of scenic spots environment. Make visitors feel the beauty of scenic spots environment through the conscious layout of trail and layered and rhythmical spread.

2.1.2 Traffic organization and sightseeing guidance of visitors

Trail in scenic spots not only accomplishes the transport task, such as environment, the maintaining, conserving and administering of building and so on through the traffic organization, but also guides the movement path for visitors. The most impact on the movement path of visitors is the trail design of direction and capacity, for visitors undertakes their journey in scenic spots according to trail direction and quantity, as well as marks of affiliated landmark. Herewith, trail in scenic spots is a necessary basic facility for visitors to complete a tour experience.

2.1.3 Visitors loading

Trail is an important carring facility in scenic spots, and complementary to its guidance function. Cui Fengjun(Cui, 1995, PP. 105-109) figured that resource space capacity was an important aspect to determine tourism carrying capacity, and trail carrying capacity should be an important part of practical carrying capacity in scenic spots. Consequently, trail in scenic spots also have a threshold of carrying capacity correspondingly, namely carrying visitors quantity under the premise of no damages to trail itself and no interference with travelling experience of visitors.

Cui Fengjun(Cui, 1995, PP. 105-109) indicated that resource space capacity was the compound concept of space limitation of tour resources to tourists and perception capacity of tourists themselves. Accordingly, how to comprehend trail carrying function should be considered from the two aspects of tourists and trail. On the one hand, carrying of tourists' space displacement should be under the premise of no influence on the quality of tourists' travelling experience. On the other hand, trail itself affects the exertion of trail carrying function.

2.2 Extending function

Extending function is a comprehensive consideration on the basis of basic function.

2.2.1 Determination of temporal and spatial distribution of visitors

Through the combination of scenic spots space, trail guides and carries the sightseeing activities of visitors, and

determines their temporal and spatial distribution, namely sightseeing route of visitors in scenic spots, as well as their residence time distribution in one spot or region. This is a dynamic index, and close associated with this static facility, trail, which indicates that quantity, width and direction design of trail determines the temporal and spatial distribution of visitors to a great extent. Direction herein means the scene spots trail leads to. Different trail direction means different resource features in scene spots, which will affect the temporal and spatial distribution of visitors in this road section.

2.2.2 Enrichment of visitors' travelling experience

Through the coordinated design with scenic spots, trail not only could guarantee the security of visitors during sightseeing, but also could enhance the ornamental value of scenic spots and enrich visitors' travelling experience. On the other hand, trail comfort design could also affect the travelling experience of visitors. Therefore, during the period of sightseeing, if it is greatly harmonious between trail design and surrounding environment and comfort is quite high, visitors' satisfaction of travelling experience will be certain to advance. Conversely, satisfaction will lower, which could affect the development of scenic spots. Consequently, trail design in scenic spots affects the quality of visitors' travelling experience to some extent.

3. Present situation and existing problems of trail in Xixi national wetland park

3.1 Trail present situation of Xixi national wetland park

Trail width in scenic spots mostly ranged from 1 to 2m, main distribution was listed in Table 1. Slate, detritus or slate, cobble or sandy soil and so on are all slate in the middle, detritus in both sides. Due to more trail in scenic spots and more spurroad to scene spots, visitors would scatter, and select sightseeing manner of battery ship, so not many visitors walk around the trail, but more visitors would appear intensively around the scene spots.

3.2 Existing problems of trail design in scenic spots

3.2.1 Large quantity, damage to original ecological system in scenic spots

There are much trail in Xixi national wetland scenic spots. For instance, three kinds of trail exist from checking position to Xixi water pavilion, and many spurroad exist in each trail. Trail in scenic spots is built by people based on the original ecological system. More trail in scenic spots will undoubtedly have a stronger impact on the ecology of scenic spots and exacerbate the damages to the original resources.

3.2.2 Great damages to vegetation around the trail

In the whole scenic spots, situation that plants around the trail were trampled by visitors is quite universal and serious. Due to soft clay around the board road, such situation is little. But damages to vegetation around the trail in main scene spots are quite serious. Situation of damages to trail itself is quite universal, especially in the trail mainly built by detritus. Seen from the trail construction in China, slate roads are majority, in which trampling situation exists to some extent.

3.2.3 Damages to trail itself

In the scenic spots of Xixi wetland, situation of damages to board and detritus roads is greatly serious. Damages to board roads is not necessarily caused by human being, for its particularity is susceptible to the interference of natural factors. But damages to detritus roads were induced by human being, and some little detritus was artificially peeled away from the ground, which facilitated other detritus break off and brought difficulty for visitors to walk, especially for children and the aged. Consequently, trail protection includes not only the protection of vegetation around the trail, but also the protection of trail itself.

3.2.4 Insufficient protection of trail sign system

Sign belongs to the additional service content of trail sign system, and plays an important guided role in the sightseeing of visitors in scenic spots. In the scenic spots of Xixi wetland, damages to trail sign system was rather serious. On the one hand, due to some wood materials universally used in scenic spots trail, trail sign system is susceptible to the interference of natural factors. On the other hand, insufficient protection of trail sign system by the administers of scenic spots is also an important causation resulting in such situation.

4. Principles of trail design in scenic spots

Trail design in scenic spots should persist in the premise of ecological protection, comprehensively consider various factors, based on scenic spots environment, and take the visitors as center with attempts to develop scenic spots. On the basis of ensuring the exertion of basic function, humanized design should be undertaken in favor of efficacious protection and reasonable development of scenic spots resources and attain the goal of promoting sustainable development of scenic spots. In combination with above trail function analysis, as well as the existing problems of trail design in Xixi national wetland park, under the premise of ecological protection, we brought forward some principles that scenic spots trail design should follow.

4.1 Macro-principles

4.1.1 Principles of protecting scenic spots environment

Due to actions of most visitors occurring intensively in or around the trail, studies on the relationship between trail design and environment in scenic spots seem more important. Ye Yongzhong of plant laboratory, Henan Agriculture University had investigated effects of trail on species features of community in Longchiman Nature Reserve, and results showed that the largest effect caused by trail was the plant coverage, and meanwhile plants with resistance to trampling started to grow which limited the growth of herb and shrub with higher individual(Zi, 1999, PP.58-60). Based on the existence of numerous environmental problems, especially in the scenic spots with relatively weaker resource characteristics, trail design should be carefully considered.

On the one hand, the embody of trail basic function should be under the premise of environmental protection without any damages, including trail design of width, quantity and so on. Sufficient survey on scenic spots resources is essential. Under the condition of properly forecasting the potential visitors in scenic spots, pertinence design and further amelioration should be undertaken; On the other hand, basic purpose of scenic spots operation should be to implement resource protection, and thus scenic spots development is promoted and resource protection is further implemented through trail design, which is the indirect effects of trail on resource protection. Taken together, resource protection is the basic premise and objective that trail design should follow in wetland scenic spots, and also the important embodiment of trail extending function.

4.1.2 Principles of enhancing visitors' experience

With the advent of economy era of travelling experience, planning and design of tourism scenic spots should sufficiently consider perception experience of visitors, and trail design, as an important traffic facility in scenic spots should embody humanity concept. Therefore, trail design of width, quantity and so on should be reasonable, and higher requirements should be raised for materials which should not only guarantee the security of visitors, but also enhance the comfort of visitors.

Due to the existence of quality problems in trail, trail itself has a carrying threshold. If visitor quantity exceeds the carring threshold of trail itself, damages to trail occurs, such as detritus breaking off the ground. Meanwhile, trail itself is an important part of resource environment in scenic spots, and damages to trail is identical to damages to scenic spots environment. Accordingly, materials used for trail in scenic spots should be carefully selected. Economic factor should not be only considered, and carring range is also an important factor, which could be depicted as "ratio of performance to price" of materials used for trail.

Anyway, travelling experiences of visitors determine the development of scenic spots, and trail design should not only consider scenic spots resources or fund regardless of visitors. Travelling experience should be promoted in scenic spots in order to enhance economic income, implement resource protection and promote benign cycle of scenic spots development. Consequently, trail design in scenic spots should be attempted to enhance visitors' travelling experience.

4.2 Micro-principles

According to the cognitive frame of social physics(Wang, 2007, PP. 34-37), generation of power certainly results from difference, difference results in gradient, gradient causes power, and power induces current. In scenic spots, difference is the difference among scenes, power is the leading-force resulted from visitors, current means temporal and spatial distribution of visitors in scenic spots. Taken together, it is evident that space displacement of visitors in scenic spots should resort to the leading-force effect resulted from the difference among scenes.

In light of this theory frame, as an important service facility in scenic spots, trail design should stick to the principles as follows:

4.2.1 Joint of line and dot

Trail in wetland should not only connect several scattered scene spots, but also be a pretty scenery. Its design should follow the principle of uniting with nature(Li, 2003, PP. 10-11), correspond to the scene spots nearby, and form an efficacious integration of lines and dots. In Xixi wetland scenic spots, trail design fails to show this principle, and match between scenery and scene spots around the trail is not very harmonious. Therefore, trail deign in scenic spots should exhibit different ecological beauty in the trail leading to different scene spots, and pose the landscape effect of "step walking, scenery changing" as possible. During the period of visitors shifting to next scenic spots, through scenery design around the trail, trail design should merge into its ecological atmosphere, and deep understand ecology connotation of the scene spot, which should be the basic connotation of trail design.

4.2.2 Serial-parallel association

Serial-parallel association mainly means that the principles trail should follow when it links various scene spots in scenic spots. Circuit design in physics link used electric apparatus in the manner of series, parallel and the combination

of those two. Applying this theory to trail design in weltand, trail is equivalent to electrical wire in circuit design, each scene spot is identical to the used electric apparatus. For trail has main road, branch road and alley, its design should embody discernible main and secondary, and have specific directivity(Wang, 2007, P. 146). Accordingly, when planning the whole scenic spots, trail could connect the main scene spots in series to form main road, and several supplementary scene spots in parallel to form branch road or alley.Trail design should highlight the main scene spots, contain subordinated sight, embody sight difference, exhibit the beauty of resources in scenic spots with level and rhythm, and induce visitors' sight-seeing actions. However, too much spurroad existed in Xixi wetland, which blocks the exertion of trail inducing function to some extent.

4.2.3 Force vector

According to the principles of social physics, larger difference, stronger gravitation. Magnitude and direction of gravitation determines the same properties of current. In scenic spots, such difference relies on the resource difference among scene spots. Therefore, connecting different sight in order should be considered in trail design, and feature of the scene spot should be highlighted around the trail, which is attempted to enhance the visitors' perception experience to the resource feature of scene spots.

In addition, force is a vector in physics, with not only magnitude but also direction, which gives a requirement for trail direction and its sign system. Sign design should consider various conditions, and offer perfect service for different visitors, especially for the aged and children. If necessary, sign system of different languages should be offered. Additionally, staff members in scenic spots should check and maintain the trail guides in time. For guides are all made by wood, and vulnerable to the erosion of wind and rain, the writing there should be renovated frequently to keep the integrity of guide and clear writing. Writings of tablet are unclear, arrows point in an indistinct way, and map marks are not clear, which all could affect the sight-seeing activities of visitors.

5. Conclusions

Taken together, from the angle of ecological protection, trail development is resources recombination in scenic spots, which could affect its original ecology system. Trail design in Xixi national wetland park affected ecological system greatly, and failed to exert its basic function very well. Consequently, trail design should integrate various factors, namely trail design of quantity, width, direction and so on which should consider not only visitors, but also resource features in different scene spots, and follow the principles of force vector. Trail should be undertaken pertinence design and planning in order to guarantee the sustainable development of tourism in scenic spots.

References

Cui, F,J. (1995). Discussion on environmental carrying capacity-a criterion for tourism sustainable development. *Economic Geography*, 15(1):105-109.

Li, Q. (2006). Approach on practical design of pavement in forest park. *Shanxi forestry science and technology*, 3:55-56.

Li, R.D., & Hu, D. (2003). A novel design for trail. *Garden*, 12:10-11.

Meng, Q.L. (2008). Discussion about path design and planning in garden green land. *Today Panorama of Modern Sciences*, 10:286.

Wang, Y.L., Li, D., & Fu, Y. (2007). Social physics and harmonious society construction. *Impact of Science on Society*, 4:34-37.

Wang, Y.S., & Fan, X.N. (2008). On the Huangshan Mountain Tourism Trail Construction Standards. *Construction & Design for Project*, 3:82-88.

Wang, Y.Y., & Hou, X.F. (2007). Discussion about path design in garden. *Private Science and Technology*, 5:146.

Wang, Z. (2007). Investigation on road design and layout in garden sight. *Science & Technology Information(Scientific teaching and researching)*, 25:492-564.

Yang, T.D., Wang, H.B., & Xia, X.W. (2004). Study on the designing of traveling path in the forest park. *Eastern China Forestry Management*, 18(4):46-48.

Zi, Q., & Zhu, Y.W. (1999). Effects of travelling path on species features of community in Longchiman nature preserve. *Henan Science*, 17:58-60.

Table 1. Trail overview of Xixi national wetland park

Materials	Width(m)	Main distribution	Flux(population/min)	Road trampled situation
Slate, detritus	1—1.5	Check position--Xixi water pavilion	6--8	25 centimetre vegetation on both sides of trail, trampled
		Yehu ferry--Bird-seeing booth	8--16	
		Yanshui fishing villa --Berth nunnery	13--21	
		Yanshui fishing villa--Pool entrance	16--32	
	4	Berth nunnery--exit	6--15	Vegetation around trail, not trampled
Slate, cobble	2.1	Xixi water pavilion--Bridge of Qiu family	8--14	25 centimetre vegetation on both sides of trail, trampled
Slate, sandy soil	1	Qiu family--Yehu ferry	6--8	25 centimetre vegetation on both sides of trail, trampled
Slate	1.5	Bird-seeing booth--Yanshui fishing villa	16--29	25 centimetre vegetation on both sides of trail, trampled
		Slate bridge near water area		
Board	1--1.5	Board road near Bird-seeing booth, board bridge near water area	6--16	Vegetation around trail, not trampled
Board, detritus	1.5	Bird-seeing booth--Yanshui fishing villa	10--24	25 centimetre vegetation on both sides of trail, trampled

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Current Situation of Environment Protection Sizing Agent and Paste

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Abstract

From the angel of environment protection, through analysing the properties of three majority types of sizing agent, such as starch(modified starch), PVA(polyvinyl alcohol) and acrylic size, we attempted to compare the sizing performance indices of several different environment protection sizing agents. We also briefly introduced several printing pastes with research values currently which could substitute sodium alginate.

Keywords: Environment protection sizing agent, Paste, Performance, Evaluation

1. Introduction

Textile sizing agents were classified into three main types, viz. Modified starch, PVA and acrylic size currently, which had an important status in the market of home and abroad, especially for starch size, accounting for about 70% total size consumption. In the international market, consumption of PVA is equivalent to acrylic size, however, in the domestic market, consumption of PVA is about two times of acrylic size. PVA belongs to refractory biodegradable organic substances, and could cause serious pollution to environment. Aimed at those problems, such as large consumption of PVA in textile size in China, environmental pollution and so on, which could affect the textile exports in China, researches on green size instead of PVA have been developed in China in recent years. Green size is a size that accord with environment protection, not only in line with functional requirements of warp sizing, but also attenuating the pollution to water and air imposed by sizing to the lowest level, guaranteeing biodegradable desizing wastewater with less pollution, and reducing the toxic substances remaining in the textile to the level within regulated limitation.

2. Research progress of environment protection sizing agent

2.1 Modification of existed sizing agent instead of PVA

At present, existed biodegradable materials, such as modified starch, acrylate, polyester and so on, have been applied to prepare green size, with attempts to substitute PVA partly or totally, which is a main approach to explore size green by many researchers.

2.1.1 Modified starch

Modified starch is the main size used for yarn sizing of natural fiber such as all cotton, for ameliorating the compatibility between starch and synthetic fiber, and flexibility of size film after modification, and could be used in the sizing process of blended yarn such as polyester/cotton instead of PVA. Modified starch size that is used frequently at home or abroad at present is starch derivatives. Researches about grafted starch have been developed to a certainty.

Currently, starch derivatives have been the main green size due to its compatibility to synthetic fiber and flexibility of size film, as well as good stability and dispersivity of viscosity. When acetyl and hydrophobic ester group were induced into acetate starch, its adhesion to natural and synthetic fiber were enhanced. Not only sizing wearability elevated, which made fuzzy yarns more comfortable, due to the induction of ester group, film forming ability also increased, which made the formed film more flexible and ameliorated the strength elongation property of sizing yarn. Currently, acetate starch could substitute 20~30% PVA size in China. In order to substitute more PVA, more attention has been paid to grafted starch by researchers. Grafted starch was prepared to be used in the sizing process of polyester/cotton blended yarn, and could substitute PVA in large scale. If graft technology was taken further amelioration, grafted starch would be applied in large proportion, and even totally used instead of PVA. Polymethacrylic acid grafted starch prepared by Mostafa was obtained by grafting methacrylic acid to corn starch in potassium permanganate/ citric acid

system and performance of such grafted starch was greatly enhanced. Fracture strength, breaking tensile rate and wearability of such sizing yarn after cotton textile sizing were all excellent. although there was a certain difference in size performance from PVA, it could be singly used in sizing process instead of PVA. Zhang et al had prepared a grafted starch size with well permeability to fiber by grafting polyacrylic acid. Such size possessed good sizing performance, size strength and tensile rate, comfortable fuzzy yarns, and could be used in sizing process of polyester/cotton completely instead of PVA. However, how to substitute in other textile totally should still need further investigation(Qin, 2006, PP. 5-6).

2.1.2 Acrylic sizing agent

Acrylic sizing agent is the general name of homopolymer, copolymer or their combination of acrylic monomers. Synthetic size with the main body of acrylic ester is the paramount kind of acrylic sizing agents, and has excellent adhesion to hydrophobic synthetic fiber, tender size film with lower strength, large deformability and moisture absorption stickiness viscosity. When sizing, it was favorable to reduce size fuzzy yarns and increase wearability. Due to the flaw of PVA size in environment protection, investigating and developing acrylic sizing agents has been imperative at present. Acrylic sizing agents includes three main types: poly acrylate, polyacrylamide and polymethyl acrylate. Poly acrylate type has excellent adhesion to hydrophilic fiber, large moisture absorption and heavy stickiness viscosity, and would have well sizing performance in combination with low proportion modified starch. PAAM (polyacrylamide) type has large moisture absorption and heavy stickiness viscosity, and good adhesion to hydrophilic fiber, with 25% of solid-containing content. It is a kind of monomer homopolymer, and its quality is easy to control. It could be made to solid formulation. Acrylate type is the high technological product of acrylic acids, and a copolymer of acrylate monomers, with two or three monomers. It has good adhesion to hydrophobic fiber, and modified moisture absorption stickiness viscosity compared to the previous two types.

Performance and quality of liquid or solid state acrylic size made in China is identical compared to foreign products. It is possible that combination of acrylic size and modified starch was applied in the sizing process of thin cotton fabric completely instead of PVA. Acrylic size has good film forming ability and adhesion, and excellent size film strength, flexibility and wearability, which is the cardinal basic condition of less or no consumption of PVA in China(Qin, 2006, PP. 5-6).

New type acrylic size STSX-1 developed by Donghua University was prepared by copolymerization of hydrophilic monomers, i.e. acrylamide and acrylic acid, and hydrophobic monomers, i.e. butyl acrylate and vinyl acetate, with attempts to obtain higher adhesion to polyester/cotton in favor of elevating size film strength, flexibility and fuzzy yarns comfort. Size film had lower fracture strength and lower leasing resistance. Moisture absorption of its size film is similar to PVA, with no thickness viscosity, lower cost and good stability. Consumption of PVA in the size formula could be reduced from 55% to 25% by using STSX-1, and less environmental pollution was imposed. Studies on acrylic ester sizing agents was also one of the focuses abroad. Hiroshi Y in Japan had used vinyl acetate copolymer heat melt sizing agents in the sizing process of polyester and cotton yarns and attained excellent effects(Zhang, 2007, PP. 15-16).

2.1.3 Polyester sizing agent

Hydrophilic polyester sizing agent is a new type textile size which is a macromolecular structure with ester group (-COO-) and hydrophilic groups, synthesized by condensation and polymerization using synthetic polyester resins or similar materials such as TPA(terephthalic acid), EG(ethylene glycol) and so on. For macromolecular of polyester contained benzene ring and ester group, similar to the molecular structure of polyester fiber, it had excellent adhesion to polyester fiber, and had good water solubility due to the presence of strong hydrophilic groups. Ester groups in such molecule were susceptible to hydrolyze in the alkali medium, and thus had excellent desizing performance. It could ameliorate the desizing performance of starch and PVA; Viscosity and surface tension of such size were all low, and had good wettability and permeability to yarns. Currently, it was mainly applied in the sizing process of polyester filament, but as far as polyester staple fiber or polyester and cotton blend was concerned, people had different opinions(Qu, 2005, PP. 257-260).

2.2 Other green environment protection sizing agent

Another approach to size green was to utilize new type material. Existing sizing agents have been modified to substitute PVA at present, and most of them were far from satisfactory due to their wearability and breaking strength. Therefore, attempts to developing sizing agents to remedy and substitute the defects of PVA by using new type materials, such as nanometer material, have been attracted many researchers' attention.

2.2.1 Inorganic nanometer material

Inorganic nanometer size is virtually a kind of size additive, and its production methods have three kinds as follows: One is to produce in the manner of dispersive way by using nano-scale human titanium oxide or silicon dioxide; Two is to produce directly by using origin materials such as titanium tetraoxide, egtazic acid ester, silicon powder and so on; Three is to blend starch and nanometer material to form solid nano-scale size additive. Nanometer sizing agents

prepared by different materials and methods had great difference in performance: solid amount had three types such as 15%, 30% and 40%; pH value had two scopes such as 2~4 and 7~8.5; Particle diameter had also two scopes such as 100~200mm and 50~80mm. In the sizing process of medium-fine total cotton textile, it could mostly take the place of "impure size PVA" ; In the sizing process of polyester-cotton fabrics, it could partly substitute PVA. And thus it had significant economic and social benefits(Yang, 2008, PP. 5-6).

2.2.2 Natural plant gum sizing agent

Main variety guar gum is a kind of natural macromolecular plant gum with excellent water solubility, and extracted from the endosperm of guar beans planted in India and Pakistan. It has excellent adhesion to both total cotton and polyester-cotton. In combination with starch and CMC, its size film had weaker fracture strength, but breaking tensile rate attained 18.59% with great wearability and 1043 times buckling resistance(Yang, 2008, PP. 5-6).

2.3 Existing problems and development of green sizing agent

Although people have developed textile size partly or totally instead of PVA, some problems still existed in their researches, for example, starch derivatives applied at present could not completely substitute PVA. Studies on modified starch should focus on developing grafted starch with excellent performance, but production process of grafted starch was complicated with high cost and low market share. Acrylic sizing agents still had the problems of re-viscosity after moisture absorption, and were also expensive. Therefore, studies on acrylic sizing agents should utilize the designable characteristic of copolymer size and solve the existing problems though optimizing their ratio. Solid acrylic sizing agents were easy to use with low transport cost, so developing such size would be one of the developing trends. Moreover, due to good film-forming property of PVA, excellence of size film performance could not be totally substituted. How to seek a proper approach to solve the refractory problems of PVA would also be of great significance. Studies on such area focused on two aspects currently as follows, one was the modification of PVA, with attempts to make it possess the property of biodegradation. Two was to develop strains which could degrade PVA. Only with unremitting efforts, amid at higher quality, more function, less compositions, seriation, less or no consumption of PVA, or developing biodegradable PVA, real green textile size of practical values could be developed.

3. Research progress of environment protection pastes

Printing pastes are important part of printing color sizing, and are close associated with printing operation performance, definition of pattern contour, hand feeling and so on. Sodium alginate has long been main printing pastes with excellent performance long utilized by human being. With the development of printing technology, higher requirements for printing pastes were imposed, and single application of such pastes were far from the requirements of printing with high quality, with the defects of undesirable rheology and printing effects of round(flat) screen printing, especially for high mesh screen printing, fine design and large-scale printing. Moreover, sodium alginate has been transformed into edible food gradually in recent years, and its price increased, which resulted in the increasing of printing production cost. Consequently, people were urgent to seek a cheap printing pastes with excellent performance instead of sodium alginate.

Guar gum was treated by hydrogen peroxide, and hydroxyls in its molecule were oxidized into aldehyde or carboxyl groups, which was applied in producing modified guar gun. When guar gum or sodium alginate treated by hydrogen peroxide was applied in active printing, K/S value resulted from oxidizing guar gum was far higher than that from sodium alginate; Dry and wet rubbing fastness was not lower; But winding length of printing fabrics was larger, namely rigid hand feeling. With the increasing of hydrogen peroxide consumption, all indices of printing fabrics were ameliorated(Huang, 2008, PP. 5-8).

PA-CMS is a kind of crosslinked carboxymethyl starch. Experiments indicated that it possessed excellent printing performance and well comprehensive printing effects, and could be applied as printing pastes for active dyes or disperse-active dyes. It was a desirable substitute for sodium alginate(Ma, 2000, PP. 267-269).

Bentonite is a kind of inorganic minerals, and after a serial treatments of impurity removal, modification, expansion, it would be a refined printing pastes. With the appearance of white granule, when added water, it was milky white after agitation. Such paste was homogeneous and exquisite, and was resistant to acid and alkali, as well as additives common used in general printings. It had good stability, and certain viscosity and consistency, but when water addition attained a certain level, its viscosity would drop abruptly, and thus caused the poor water retention property. Such paste had poor fluidity in normal state, when given force, its viscosity decreased. As seen from rheological curve, it belonged to typical pseudoplastic fluid. Due to poor fluidity and water retention property, when single used as printing paste, it would cause bleeding and uneven pulp fluid, but in combination with certain proportion seaweed, its rheological property would be greatly modified(Yun, 1999, PP. 25-26).

The most significant advantages of bentonite as printing paste is no binding force with dyes and fibers with high color yield after printing. Paste is easy to wash, and resultant wastewater cause no pollution to environment. Disadvantages are as follows: (1) poor permeability; (2) low adhesive force; (3) poor water retention property, and weak dilution

resistance. Therefore, it was tough to attain good printing effect using single bentonite, and it should be blended with other pastes to be compound paste. Above mentioned defects would be overcome by blending which could also protect bentonite, and enhance its stability to electrolytes. After bentonite blended with sodium alginate in a proper proportion, printing products possessed rich color yield, and its permeability and color fastness index attained the level when using sodium alginate; Blending size could lower the cost, attenuate the burden of wastewater treatment; Furthermore, it had great storage stability, and was hard to deteriorate. However, if in an improper proportion, phenomena of paste pressing and net destroying would occur, which need further investigation(Huang, 2008, PP. 5-8).

Synthetic thickener is a kind of synthetic macromolecule compounds, and monomers used are mainly acrylic acids, maleic acid and less crosslinked monomers. Used for thickener, it had good rheology, low forming paste rate and low solid mass percent of color paste. No hydroxyl but lots of carboxyls existed in molecule, which facilitated they had quite high negative charge density in alkali condition, and offered possibility for the printing of active dyes.

Synthetic paste C, using polysaccharides of cotton linter as main original paste, is a new type anionic printing paste through reactions of crosslinking, etherifying, carboxylation and so on. For general printing fabrics, apparent color strength was used to evaluate colorizing effect of dyes. Through electronic color measurement of printing samples, K/S values in the surface were observed, percent of K/S value all used sodium alginate as standard. Apparent color strength of synthetic paste C was higher than that of sodium alginate, with the increasing of original paste concentration, viscosity of synthetic paste C attained double increase compared to sodium alginate. For its good storage stability, resistant to all kinds of chemicals, it could be used in weak alkali, strong alkali or acid conditions, and suitable for many printing processes. Therefore, it was a kind of multifunctional printing paste(Wang, 2002, PP. 72-73).

References

Huang, Y., Zhu, P., & Wang, B., et al. (2008). The development of reactive printing pastes. *Textile Auxiliaries*, 25(5):5-8.

Ma, C.H. (2000). The study and application of new type printpaste. *Henan Science*, 18(3):267-269.

Qin, Z.J. (2006). Development and application of green sizing agent. *Progress in Textile Science & Technology*, 4:5-6.

Qu, C.X. (2005). Application analyses on environment protection sizing agent. *Cotton Textile Technology*, 33(5):257-260.

Wang, H., Zheng, Y.D., & Ren, X.Z. (2002). Synthesis Gum C Instead of Sodium Alginate in Reactive Printing. *Journal of Zhongyuan Institute of Technology*, 13(2):72-73.

Yang, Z.Q. (2008). Green environment protection textile size. *Textile Decoration Science & Technology*, 1:5-6.

Yun, J.R., & Zhou, L.Q. (1999). Application of Bentonite Paste in Printing with Reactive Dyes. *Textile Dyeing and Finishing Journal*, 21:25-26.

Zhang, C., Yu, S.M., & Gao, X.L. (2007). Research progress of green textile size at home and abroad. *Progress in Textile Science & Technology*, 6:15-16.

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Investigation on the Performance of Diesel Engine Using Various Bio Fuels and the Effect of Temperature Variation

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Abstract

This paper discusses the performance characteristics of a single cylinder diesel engine using rice bran and pungam oil blended with diesel fuel. The experiments were carried out for the various blends i.e., B20, B40, B60, B80 and the results were compared with the neat diesel. The blended fuel is preheated before it is being injected to cylinder. The preheating ensures the enhancement of combustion efficiency and the over all performance of the engine.

Keywords: Diesel engine, Vegetable oils, Performance Characteristics, Blending, Heating temperatures

1. Introduction

Ever since the world witnessed the oil crisis, there has been unprecedented stockpiling of oil taking place by the developed countries. Production of world's estimated oil reserves is expected to be peak between 2010 and 2030. Especially the demand of diesel fuel has grown from 39.81 million metric tons in 2001-2002 to 52.32 million metric tons in 2007-2008. Therefore it is important to explore the feasibility of substitution of diesel with an alternative fuel, which can be produced with in the country on a massive scale for commercial utilization.

Vegetable oils are considered as good alternatives to diesel as their properties are close to diesel. Thus, they offer the advantage to be used in existing diesel engine without any engine modifications. They have a reasonably high cetane number. The flash point of vegetable oils is high and hence it is safe to use them. Vegetable oils typically have large molecules, with carbon, hydrogen and oxygen being present. They have a structure similar to diesel fuel, but differ in the type of linkage of the chains and have a higher molecular mass and viscosity. The presence of oxygen in vegetable oils raises the stoichiometric fuel air ratio. Contrary to fossil fuels, vegetable oils are free from sulfur and heavy metals. The heating value is slightly lower than diesel. It has been reported that the methyl and ethyl esters of vegetable oil can result in superior performance than neat vegetable oils.

Larry Wagner et al., (1984) studied the effect of soybean oil esters on performance and emissions of a four-cylinder direct injection turbocharged diesel engine. They found that the engine performance with soybean oil esters did not differ to a great extent from that of diesel fuel performance. Clark et al., (1984) studied the effect of methyl and ethyl esters of soybean oil on engine performance and durability in a direct injection four-cylinder diesel engine. They observed that the engine fuelled with soybean esters resulted in a slightly less power combined with an increase in fuel consumption. Emissions were found to be similar to diesel. Nobukazu Takagi and Koichiro Itow (1984) conducted experiments on a single cylinder direct injection diesel engine with rapeseed oil and palm oil as fuels. Ramesh et al.(1989) investigated the performance of a glow plug assisted hot surface ignition engine using methyl ester of rice bran oil as fuel. Normal and nimonic crown pistons were used for their tests. They reported improvement in brake thermal efficiency about 1% when the glow plug is on. The percentage improvement in brake thermal efficiency was more in the case of normal piston compared to nimonic piston. Brake thermal efficiency was higher with nimonic piston at low power outputs than normal piston. They observed reduced ignition delay in both cases with glow plug assistance. No significant changes in hydrocarbon and carbon monoxide emissions with methyl ester of rice bran oil using glow plug ignition were noted. Perkins and Peterson (1991) conducted a 1000-hour durability test on a compression ignition engine when fueled with methyl ester of winter rapeseed oil. Based upon the evaluation of engine performance, wear and injector deposits as indication of engine durability, they noted that the methyl ester of winter rape oil appeared to be equal to diesel fuel. They also reported that the major disadvantage for the methyl ester of winter rape oil was its cloud

and pour points, which eliminate its use in cold weather. Kyle Scholl and Spencer Sorenson (1993) investigated the combustion characteristics of soybean oil methyl ester in a four cylinder naturally aspirated direct injection diesel engine and compared the results with the conventional diesel fuel. Masjuki and Abdulmuin (1996 a), (1996 b) conducted experiments on a water-cooled direct injection, ISUZU, four-cylinder, four-stroke engine. They reported that palm oil derived fuels result in performance comparable to diesel with improved combustion stability of the engine. They observed that the emission characteristics were good except that CO levels. Ken Friis Hansen and Michel Grouleff Jensen (1997) conducted several studies on a six-cylinder direct injection horizontal turbocharged diesel engine. They used methyl ester of rapeseed oil for their experiments. They found that there was a decrease in hydrocarbon and carbon monoxide emissions but an increase in NOX and particulate emission. Varaprasad et al. (1997) studied the effect of using Jatropha oil and esterified Jatropha oil on a single cylinder diesel engine. They found that the brake thermal efficiency was higher with esterified Jatropha oil as compared to raw Jatropha oil but inferior to diesel and also reported low NOX emissions and high smoke levels with neat Jatropha oil as compared to etserified Jatropha oil and diesel. Shaheed and Swain (1999) conducted the experiments on a single cylinder air cooled naturally aspirated direct injection diesel engine using coconut oil and methyl ester of coconut oil and diesel. They reported that the engine performed well on the three fuels except for the initial engine starting problems with coconut oil. Swain and Shaheed (2000) also conducted experiments on a single cylinder direct injection Lister Petter diesel engine with the same oil. They observed that the esters derived from coconut oil have many characteristics similar to diesel fuel with little performance and emission differences. They concluded that the fuel derived from the coconut oil is a potential alternative for operating a standard diesel engine without any engine modifications. Abdul Moneyem and Van Gerpen (2001) conducted experiments to characterize the effect of oxidized Bio diesel on engine performance and emissions. They used methyl soyate (Bio diesel) for testing a turbocharged direct injection diesel engine. They found that the performance of neat Bio diesel and it's blend with diesel were similar to neat diesel fuel operation. They also found a significant reduction in Bosch smoke number with neat Bio diesel and its blend when compared with diesel.

Recep Altin et al. (2001) conducted experiments on a single cylinder direct injection diesel engine to evaluate the performance and exhaust emissions using refined sunflower oil, cottonseed oil, soybean oil and their methyl esters. They found little power loss, higher particulate emissions and less NO_X emissions with neat vegetable oils. Kaligeros et al. (2003) conducted experiments on a single cylinder indirect injection Petter diesel engine using olive oil and sunflower oil as fuels in different proportions with marine diesel. They reported lower unburned hydrocarbon, carbon monoxide, particulate and nitrogen oxide emissions with blends than neat vegetable oils.

2. Engine Details

Make	:	COMET
No. of Cylinder	:	one
Orientation	:	vertical
Cycle	:	4 Strokes
Ignition System	:	compression Ignition
Bore and stroke	:	80 mm × 110 mm
Displacement volume	:	553 cc
Compression ratio	:	18:1
Arrangement of valves	:	overhead
Combustion Chamber	:	hemi spherical open Chamber (Direct Injection)
Rated power	:	3.5 kW @ 1500 rpm
Cooling Medium	:	water cooled

Fuel tank with heater, temperature regulator and stirrer unit are the accessories used in the experimental set up for blending and heating the oil. The oil is blended with diesel in different proportions. The temperature is varied from 27°C to 80ºC. The blended oil is stirred continuously for better mixing. Continuous heating is required in order to reduce the viscosity of the blended oil so that the engine performance will improve.

3. Experimental Investigation

The engine was run with the various blends (B20, B40, B60 and B80) and with pure diesel by varying the temperatures from 27°C to 80°C at different loads and with rated speed of 1500 rpm. The observations were made on Brake power, Fuel consumption and Exhaust gas temperature for the various loads and the performance parameters like Brake power, Brake thermal efficiency, Total fuel consumption and Specific fuel consumption have been calculated for all the blends and the performance graph have been drawn.

4. Results and Discussion

4.1 Rice Bran Oil

4.1.1 Break Power Vs Specific Fuel Consumption

The following figures 1 to 4 show the Break Power (B.P) versus Specific Fuel Consumption (S.F.C) using Rice Bran Oil at different temperatures.

4.1.2 Break Power Vs Specific Break Thermal Efficiency

The following figures 5 to 8 show the Break Power (B.P) versus Break Thermal Efficiency (B.T.E) using Rice Bran Oil at different temperatures.

4.2 Pungam Oil

4.2.1 Break Power versus Specific Fuel Consumption

The following figures 9 to 12 show the Break Power (B.P) versus Specific Fuel Consumption (S.F.C) using Pungam Oil at different temperatures.

4.2.2 Break Power versus Break Thermal Efficiency

The following figures 13 to 16 show the Break Power (B.P) versus Break Thermal Efficiency (B.T.E) using Pungam Oil at different temperatures.

5. Conclusions

It is concluded from the above graph that the highest engine efficiency is obtained for the B60 of pungam oil and also it is evident that the efficiency increases with increase in the temperature. Where as for the rice bran oil, the variation in the engine efficiency is very minimum with change in temperature and the performance of the engine is found to be good for the B40 blend. However the over all performance of the engine is found to be good when the oil and diesel blend is supplied to the cylinder after pre heating.

References

Abdul Monyem., Jon, H and Van Gerpen. (2001). 'The effect of Biodiesel oxidation on Engine Performance and Emissions', *International Journal of Biomass and Bio Energy*, No.20, pp. 317-325.

Amin-Nejad S., Smith J.S., and Lucas.J. (2003). "A Visual Servoing System for Edge Trimming of Fabric Embroideries by Laser." *Journal of Mechatronics*, Pergamon Press, New York. ISSN 0957-4158. 13(6): pp533-551.

Clark, S.J., Wagner, L., Schorck, M.D. and Piennaar, P.G. (1984). 'Methyl and Ethyl Soybean Esters as Renewable Fuels for Diesel Engines', *Journal of American Oil Chemist Society*, Vol. 61, No.10, pp.1632-1638.

Kaligeros, S., Zannikos, F., Stournas, S., Lois, E., Anastopoulosd, G., Teas Ch and Sakellaropoulos, F. (2003). 'An Investigation of Using Bio diesel/Marine Diesel blends on the Performance of a Stationary Diesel Engine', *Journal of Biomass and Bio energy*, No.24, pp. 141-149.

Ken Friis Hansen and Michael Grouleff Jensen. (1997). 'Chemical and Biological Characteristics of Exhaust Emissions from a DI Diesel Engine Fuelled with Rapeseed Oil Methyl Ester (RME)', *Society of Automotive Engineers*, Paper No. 971689. 17.

Larry E. Wagner., Stanley J. Clark and Mark D. Schrock. (1984). 'Effect of Soybean Oil Esters on the Performance, Lubrication Oil and Water of Diesel Engines', *Society of Automotive engineers*, Paper No. 841385.

Masjuki, H., Abdulmuin, M.Z. and Sii, H.S. (1996 a). 'Indirect Injection Diesel Engine Operation on Palm Oil Methyl Esters and Its Emulsions', *Proceedings of Institute of Mechanical Engineers*, No. 211, pp.291 – 299.

Masjuki, H., Abdulmuin M.Z and Sii, H.S. (1996 b). 'Investigation on Preheated Palm Oil Methyl Esters in Diesel Engine', *Proceedings of Institute of Mechanical Engineers*, No.210, pp.131 – 138.

Nobukazu Takagi, and Koichiro Itow. (1984). 'Low Carbon Flower Buildup Low Smoke and Efficient Diesel Operation with Vegetable Oils by Conversion to Monoesters and Blending with Diesel Oil or alcohols', *Society of automotive engineers*, Paper No.841161.

Ramesh, A., Nagalingam, B. and Goparakrishnan, K.V. (1989). 'Performance of Glow Plug Surface Ignition Engine with Methyl ester of Rice Bran Oil as Fuel', Proceedings of XI National Conference on I.C. Engines and Combustion, Indian Institute of Technology Madras, Tamil Nadu state, India.

Recep Altin., Selim Cetinkaya and Huseyin Serdas Yucesu. (2001). 'The Potential of Using Vegetable oil Fuels as Fuel for Diesel Engines', *International Journal of Energy Conversion management*, No.42, pp.529 – 538.

Shaheed, A and Swain, E. (1999). 'Combustion Analysis of Coconut Oil and Its Methyl Esters in a Diesel Engine', *Proceedings of Institute of Mechanical Engineers*, Vol 213, Part A, pp. 417-425.

Swain, E and Shaheed, A. (2000). 'An Experimental Study to Evaluate the Use of Coconut Based Fuels as Alternatives to Diesel Oil', *Journal of the Institute of Energy*, No.73, pp. 100-105.

Varaprasad, C.M., Muralikrishna, M.V.S and Prabhakar reddy, C. (1997). 'Investigations on Bio diesel (Esterified Jatropha Curcus Oil) in Diesel Engines' XV National Conference on I.C. Engines and Combustion, Anna University, Chennai, Tamil Nadu, India.

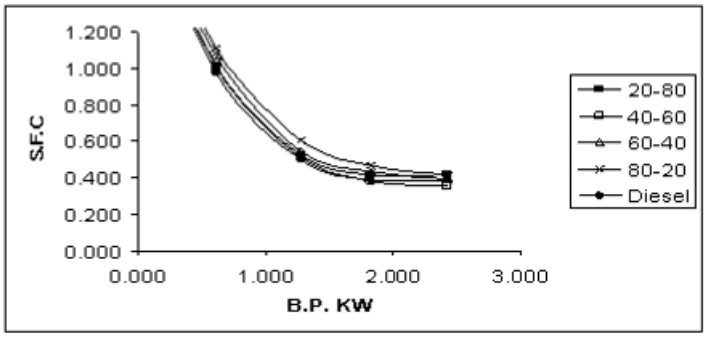
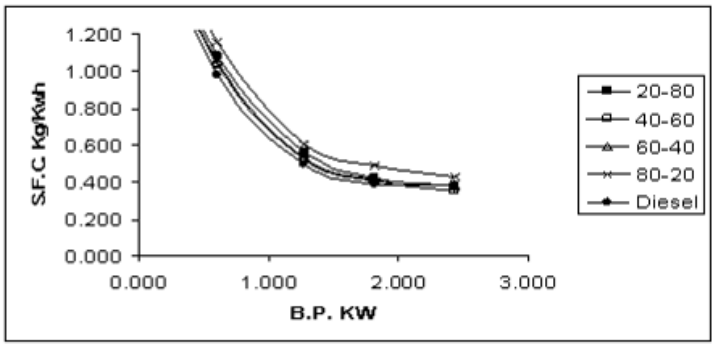


Figure 1. B.P Vs S.F.C at $27^{O}C$



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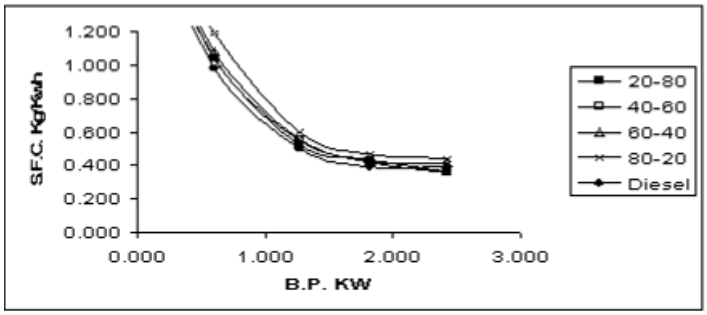

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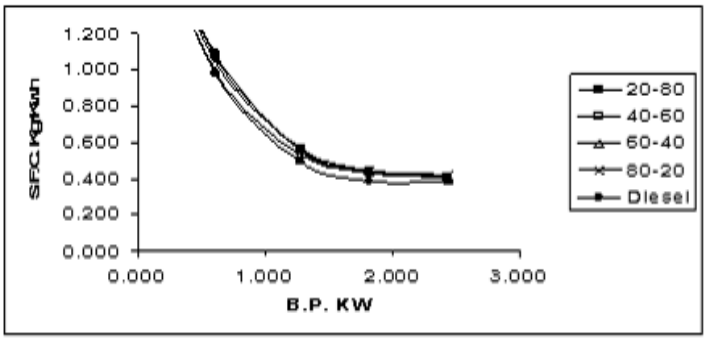


Figure 4. B.P Vs S.F.C at $80^{O}C$

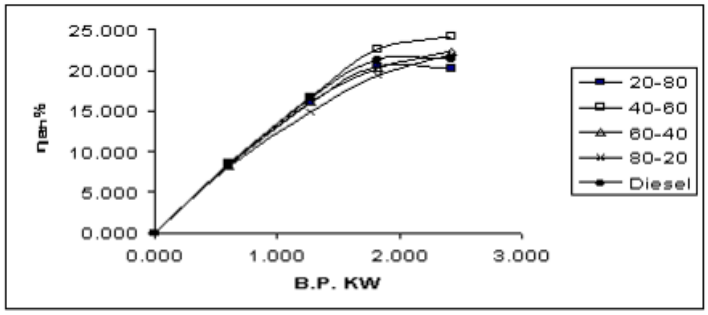


Figure 5. B.P Vs B.T.E at 27^{O}C

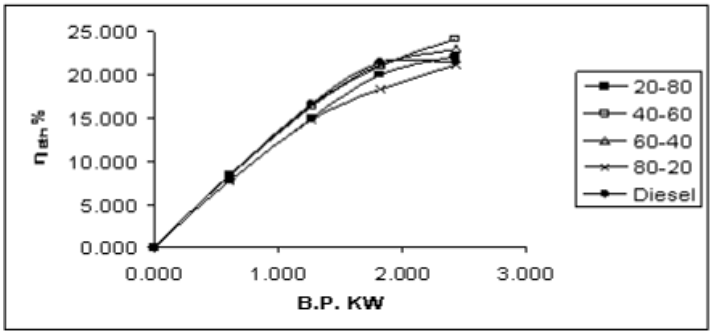
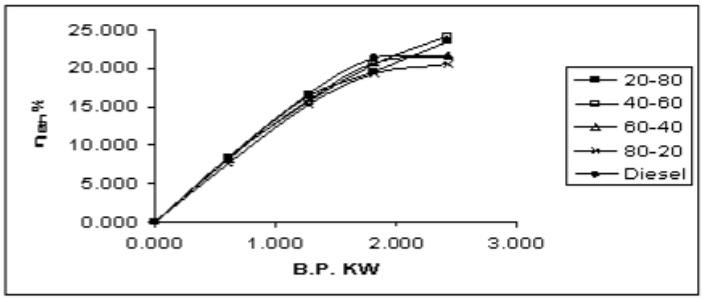


Figure 6. B.P Vs B.T.E at 40^{O}C



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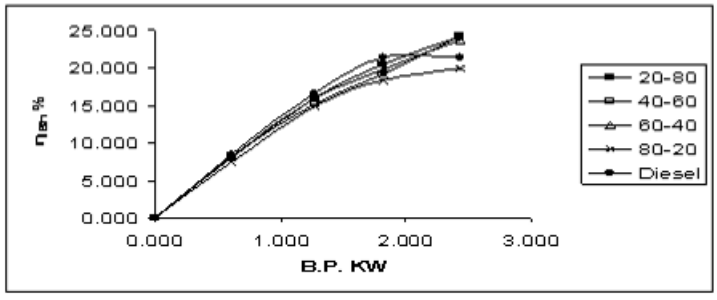
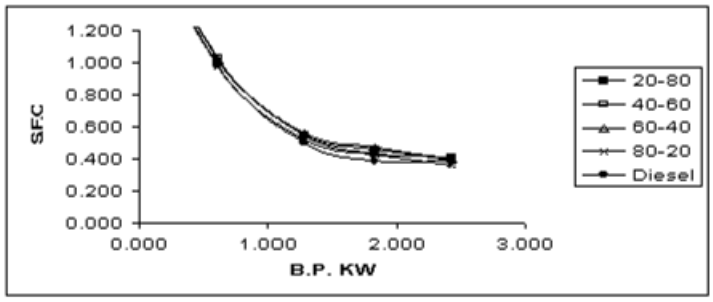


Figure 8. B.P Vs B.T.E at 80^{O}C



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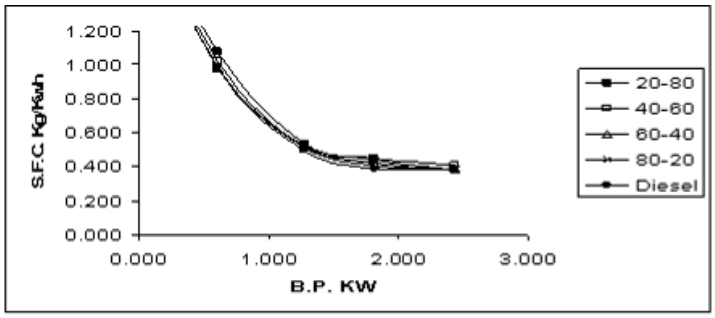

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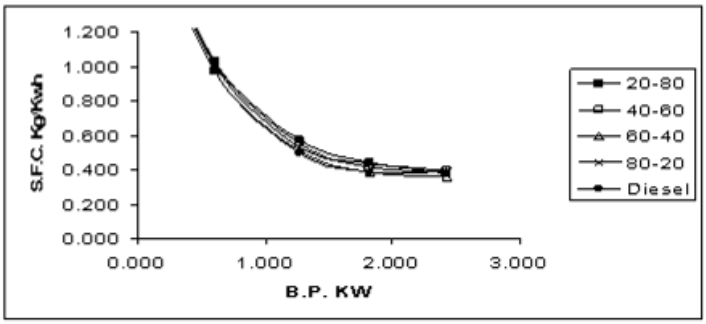

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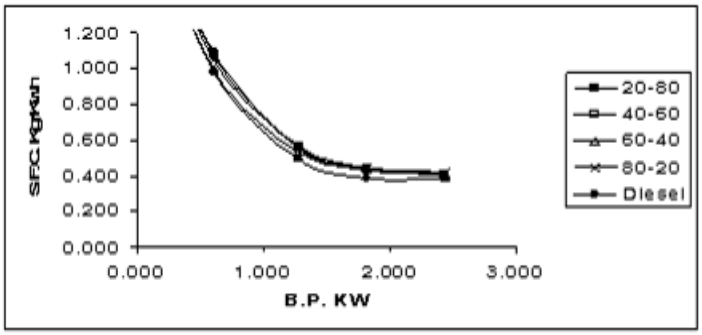

Figure 12. B.P Vs S.F.C at $80^{O}C$

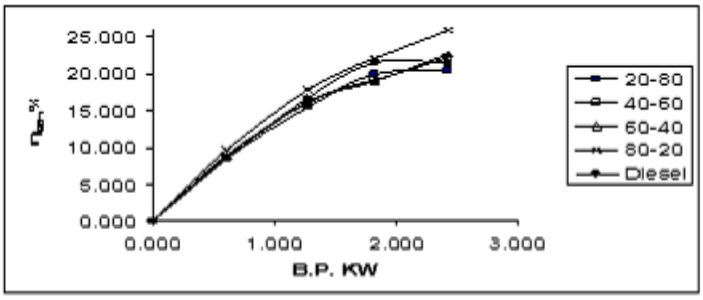

Figure 13. B.P Vs B.T.E at 20^{O}C

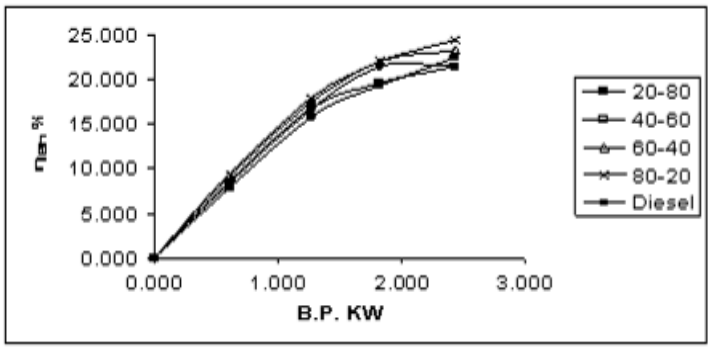

Figure 14. B.P Vs B.T.E at 40^{O}C

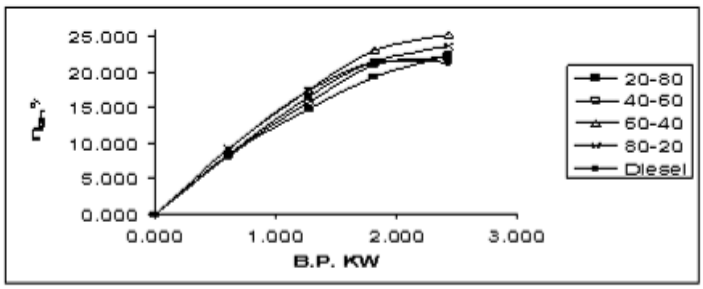

Figure 15. B.P Vs B.T.E at 60^{O}C

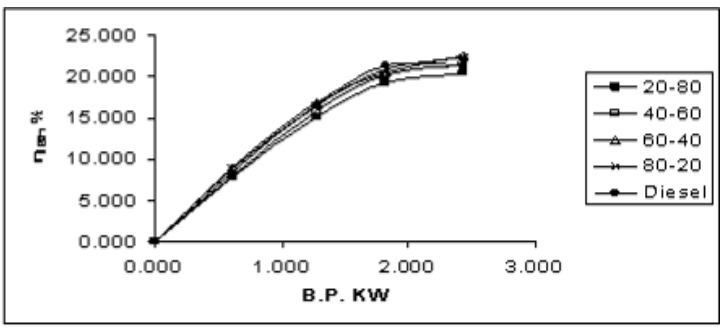

Figure 16. B.P Vs B.T.E at 80^{O}C

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Application of Vacuum Membrane Distillation in Water Treatment

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Abstract

In the present paper, we reviewed the principles and classification of membrane distillation, with an emphasis on the factors affecting it and approaches to enhance its efficacy, and finally outlook its research prospects.

Keywords: Vacuum membrane distillation, Classification, Affecting factors, Research prospects

1. Introduction

Water is the source of life, the basis of human survival, and the principal material base to guarantee the economy substantial development of a country. However, a practical and urgent strategic problem emerged in the world, viz. Water resource crisis. In the early 20th century, there was the parlance in the world that "Struggling for coal in 19th century, oil in 20th century and water in 21th century"(Li, 2001, PP. 166-167). However, 2/3 surface of the earth is covered by water, and solutions to water resource crisis is actually how to utilize water resource. As is well known to us all, 97.5% total water reserves in the globe is salt water, and among 2.5% fresh water, 2% water is tough to utilize for it is covered by icecaps, glaciers and ice-snow in two poles. The fresh water that could be utilized by human being in fact accounts for only 0.5% of total water reserves in the globe, while a majority of them belong to exhausted ground water which could not be renewable(Lin, 2000, PP. 7-12). Compared to the early 20th century, the consumption of fresh water increased 6-7 times, and was two times of population increment. UN(United nation) have warned several times that almost 1/3 population of the world would face the problem of water deficit in 2025 if without any powerful measurements in each country. China is listed in the table of 13 countries under the most severe water deficit. Gross fresh water in China make the top 6 in the world, but fresh water per capita is only 1/4 of the average of the world, ranking 109 in the world. Moreover, temporal and spatial distribution of water is rather uneven(Bart, 2002, PP. 207-218). Accordingly, solutions to fresh water resources are urgent in order to guarantee the economy substantial development in China. Efficacious and strategic approach to settle fresh water resource crisis is the distillation of water.

Membrane distillation(MD) is a new membrane separation technology(Lawson, 1997, PP. 1-25; Schneider, 1986, PP. 514-521; Drioli, 1985, PP. 339-346), although it has been developed for only 10 years, due to its particular separation effects and promising application prospects, it have been paid more and more attention. Meanwhile, along with the progressing claims of environment protection recently, requirements for environment protection became higher and higher, and new technology is essential and urgent. Membrane distillation showed huge potential values in this area. Vacuum membrane distillation(VMD), as the emphasis and focus of MD, showed lower energy consumption and higher efficacy, and could be called as apotheosis of drag reducing and energy saving.

2. Basic principles of MD

MD was a membrane separation process combining with membrane technology and evaporation, and the membrane used was hydrophobic microporous membrane which could not be wetted by pending solutions. One side of membrane exposed to warm pending solutions directly(hot procedure side), the other side exposed to cold water solutions directly or indirectly(cold procedure side). Volatile components in hot procedure side evaporated in membrane surface, enter cold procedure side through membrane, and condensed into liquid phrase. Other components block off in hot procedure side by hydrophobic membrane and thus realize the objective of compounds separation and purification. MD was the process that transferred heat and quality simultaneously, and mass transfer impetus was steam differential imposed by components permeating through the both membrane sides.

3. Classification of MD

3.1 Direct contact membrane distillation(DCMD)

Both membrane sides contact with hot and cold water directly, respectively. It was suitable for water infiltration, such as desalination or condense water solutions. DCMD has successfully been applied in the wastewater treatment, and resulted in some infiltrations with low pollution to environment, such as treating textile wastewaters , pharmacy

wastewater containing taurine, water with heavy metal ions and so on. DCMD could be also used to separate heat-sensitive materials, such as the condensation of juice, blood and so on(Chen, 1996, PP. 307-313).

3.2 Air gap membrane distillation(AGMD)

There was an air gap between cold procedure side and condensation wall, which could enhance the heat conduction drag. Therefore, flux of AGMD was usually smaller than that of other MDs, but AGMD had a broader application than DCMD, for AGMD condensed infiltration in the condensation surface, not directly. AGMD has been successfully applied in the production of pure water and the concentration of all kinds of nonvolatile solutes.

3.3 Sweep gas membrane distillation(SGMD)

Cold procedure side of membrane swept air in order to carry away the transferred steam. It used membrane to separate air or steam, in combination with lower heat conduction loss and lower mass transfer resistance. Infiltration condensed in the outer condenser. The charge of condenser was quite large, for in the large quantity of sweeping gas, only less vaporized filtration existed. Therefore, studies on SGMD were less available.

3.4 Vacuum membrane distillation(VMD)

Steam was continuously exerted from the cold procedure side of membrane by vacuum system, and condensed outside of the membrane separator. Porous membrane used in VMD served as the support of gas-liquid surface. This membrane possessed some selectivity, based on Knudsen diffusion rate of diffusing substances, but separation extent was mainly determined by the gas-liquid equilibrium condition in the membrane-solution surface. Compared to other MDs, one of the advantages was that heat conduction loss by membrane could be neglected. As a new separation approach, it was mainly applied to eliminate the volatile components in dilute aqueous solutions(Liu, 1991, P. 25) with larger membrane flux and greater industrial practical significance.

4. Affecting factors during the process of VMD

4.1 Rejection rate

Rejection rate was separation performance parameter of nonvolatile solute water solutions. Due to hydrophobicity of distillation membrane, its rejection rate was higher than that of other membrane separation(Xu, 1998, PP. 1-6). Its affecting factors are mainly two as follows: one is pore size, and 0.2-1.0μm pore size is usually considered to be proper, and 0.2-0.4μm is used much. Two is that pressure difference of membrane two sides could not exceed the pressure P*($P^*=2\gamma\cos\theta R$) when liquids entered into membrane pore. Furthermore, rejection rate was related to solute concentration in the feeding system, feed flow rate and so on.

4.2 Membrane permeation flux

Membrane distillation has higher rejection rate but relatively lower flux, and flux affecting factors were outlined as follows(Zhang, 2001, PP. 16-21):

(1)Temperature: temperature was the main factor affecting permeation flux. For DCMD, enhancing the temperature of solutions in hot procedure side or temperature difference between two sides, could result in significant increment of water flux, but not in a linear relationship.

(2)Vapour pressure deficit: permeation flux increased with the increasing of vapour pressure deficit between both membrane sides, and a linear relationship was obtained.

(3)Feed concentration: with the increasing of feed concentration, flux of nonvolatile solute water solutions decreased, while that of volatile increased.

(4)Feed flow rate: Increasing feed flow or cooling water flow could result in flux increment.

(5)Distillation time: due to the process of distillation, membrane pore infiltration resulted in the reflux from the permeation side stream to feed, and membrane pollution caused the reduction of flux. Therefore, with the increasing of distillation time, flux reduction occurred.

(6)Membrane material and structure: hydrophobic microporous membrane was used in MD, and structure parameters affecting water flux were mainly as follows: pore size, porosity and membrane thickness.

4.3 Thermal efficiency

MD accompanied phase transition with heat energy consumption, and thermal efficiency affected directly its practical application. Thermal efficiency was an important factor which determined whether MD was competitive. Currently, thermal efficiency of MD was rather low(30% or so), which was one of the key problems hindering its large scale industrial application. If pore size and porosity was larger, diffusion coefficient of steam in membrane pore was higher, and membrane thermal conductivity was lower. Variation of membrane thickness would affect the temperature of membrane surface, and thus have an indirect impact on evaporation efficiency. Taken together, thermal efficiency was close associated with membrane parameters, and therefore, it could be enhanced by ameliorating membrane parameters.

5. Approaches to enhance VMD performance

5.1 Attenuate concentration and temperature polarization

During the process of VMD, in the interface of gas-liquid, temperature and concentration of solutions were all lower than main feed solutions, which was the concentration and temperature polarization during the process of VMD. These two polarizations would all resulted in the reduction of steam differential in both membrane sides, and thus caused the decline of permeation flux. According to MD mass transfer mechanisms, it would be beneficial to enhance MD flux by changing the flow state of feed solutions and attenuating concentration and temperature polarization. Bandini S et al(Bandini, 1999, PP. 58-62) augmented turbulent extent of thermal fluid by increasing feed flow, decreased the thickness of laminar boundary layer, and thus attenuated the concentration and temperature polarization of boundary layer, increased diffusion coefficient of thermal fluid and enhanced the mass transfer and heat transfer during the process. Martinez et al (Martinez, 1998, PP. 45-56) had placed spacers in the channel of feed solutions, and distillation flux increased 31%~41%. Narayan et al(Narayan, 2002, PP. 149-156) applied ultrasonic technology to increase permeate and distillation flux of different system by 22%~205%.

5.2 Add salt to feed solutions

For recovering volatile solutes in VMD process, salts could be added to feed solutions to reduce water vapour pressure and thus enhance the permeation flux of volatile components. For instance, Tang et al(Tang, 2002, PP. 11-14) have observed that the presence of $AlCl_3$ increased HCl permeation flux in the experiments of recovering HCl by VMD.

5.3 Select proper operation conditions

Cold procedure side pressure played an critical role in membrane separation performance. With the decreasing of vacuum in cold procedure side, cold procedure side pressure augmented, and membrane flux and rejection rate all decreased. Consequently, when such pressure was larger than vapour critical pressure in membrane surface, decreasing such pressure would be beneficial to enhance membrane rejection rate and flux(Liu, 1997, PP. 65-68). Enhancing temperature could lower viscosity of fluid, reduce liquid membrane drag and thus increase mass transfer coefficient. For volatile components, with the increasing of concentration, membrane flux and rejection rate increased(Zhong, 2003, PP. 44-46); For nonvolatile components, with the increment of feed concentration, membrane flux lowered, because with the increasing of feed concentration, water saturated vapour pressure decreased, and separation process impetus lowered, which was not good for separation(Du, 2000, PP. 14-17); Operation manner had significant impacts on flux. Wirth et al (2002, PP. 139-145) have investigated total heat and mass transfer coefficient in two operation manners in the experiment of desalination by water solutions, namely inside /out and outside/in, and speculated that outside/in manner was of more industrial production values.

5.4 Ameliorate membrane performance

Hydrophobicity is primary for membrane materials and microporous membrane during VMD process. Materials are more hydrophobic, performance of materials used for VMD is better; Membrane pore is another cardinal factor affecting flux and rejection rate during MD process. Increasing pore size and porosity would be beneficial to the increment of flux. Study by Li et al(2003, PP. 153-156) indicated that polyethylene membrane with larger micropore diameter and higher porosity had quite high permeation flux under the same operation condition; Membrane loading density also affected VMD performance, Zhu et al(1999, PP. 51-54) found that pressure difference between both membrane sides was large when membrane loading density was quite low, and thus such difference resulted in large permeation flux.

6. Research prospects of VMD

Compared to other MD processes, operation temperature of VMD process could be lower, and at the same temperature, its flux would be larger. VMD could be convenient to utilize cheap heat sources such as solar energy, geothermal energy, waste heat and so on(Mathiouslakis, 2007, PP. 346-365). Therefore, in combination with such cheap energy, VMD would have greater advantage in water treatment. For MD was a process of phase tansition, utilization of heat energy could reduce due to latent heat of vaporization. To design proper energy recovery facilities would be of great practical values in energy saving(Duan, 2005, PP. 15-16; Liu, 2008, PP. 32-37).

VMD is a new membrane separation technology, and its corresponding application research have obtained excellent achievements, which showed its promising application prospects. We believed that VMD would attain better application in water treatment and bring greater impetus for substantial development along with the development of membrane material and deep amelioration of process mechanism.

References

Bandini, S., & Sarti, G.C. (1999). Heat and mass transport resistances in vacuum membrane distillation per drop. *AIChEJ*, 45 (7):58-62.

Bart, V.B., & Carlo, V. (2002). Distillation vs. membrane filtration: overview of Proeess evolutions in seawater desalination. *Desalination*,143(2):207-218.

Chen, C.X., Yu, L.X., & Dai, T.Y. (1996). Review of new membrane and membrane process. *Technology of Water Treatment*, 22(6):307-313.

Drioli, E., & Wu, Y.L. (1985). Membrane distillation: An experimental study. *Desalination*, 53:339-346.

Du, J., Liu, Z.H., & Tao, C.Y., et al. (2000). Investigation on the treatment of aqueous Cr^{3+} solutions with PVDF microporous membranes. *Chemical Research and Application*, 20(3):14-17.

Duan, X.L., & Chen, B.B. (2005). Study on the experimental of ultrasound enhancing vacuum membrane distillation. *Chemical Engineer*,118(7):15-16.

Lawson, K.W., & Lloyd, D.R. (1997). Review: Membrane Distillation. *J.Membr.Sci.*, 124:1-25.

Li, L.M., Xu, Z.K., & Liu, Z.M., et al. (2003). Mcroporous polypropylene and polyethylene hollow fiber membranes. Part 3. Experimental studies on membrane distillation for desalination. *Desalination*, 155:153-156.

Li, Y.L. (2001). The Present Situation and the Application about Seawater Desalting. *Water Conservancy Science and Technology and Economy*, 7(4):166-167.

Lin, S.Q. (2000). The present situation and future of seawater desalination. *Technology of Water Treatment*, 26(1):7-12.

Liu, G.X., & Liu, L.S. (1991). *Membrane separation technology and its application*. Beijing:Chemical Industry Press, 125.

Liu, L.Y., Ding, C.W., & Chang, L.J., et al. (2008). Progress in membrane separation enhanced by ultrasound. Chemical Industry and Engineering Progess,27(4):32-37.

Liu, M.L., Huo, Z.X., & Chen, D.J., et al. (1997). The influence of the degree of vacuum of the cold side on vacuum membrane distillation process. *Membrane Science and Technology*, 17(3) :65-68.

Martinez, D.L., Vazquez, G.M.I., & Florido, D.F.J. (1998). Study of membrane distillation using channel spacers. *J Memb Sci.*, 144 (1-2) :45-56.

Mathiouslakis, E., Belessiotis, V., & Delyannis, E. (2007). Desalination by using alternative energy: review and state-of-the-art. *Centre National de La Recherche Scientifioue*, 203(1-3):346-365.

Narayan, A.V., Nagaraj, N., & Hebbar, H.U., et al.(2002). Acoustic field-assisted osmotic membrane distillation. *Desalination*,147(1-3) :149-156.

Schneider, K., & Gassel, T.J. (1984). Membrane distillation. *Chem.Ing.Tech.*, 56:514-521.

Tang, J.J., Zhou, K.G., & Zhang, Q.X. (2002). HCl separation from $AlCl_3$-HCl-H_2O system by vacuum membrane distillation. *Membrane Science and Technology*, 22 (3) :11-14.

Wirth, D., & Cabassud, C. (2002). Water desalination using membrane distillation: comparison between inside/out and outside/in permeation. *Desalination*,147(1-3):139-145.

Xu, Y.Y., Xiang, H., & Chen, Y.S. (1998). The study and development of membrane distillation. Membrane Science and Technology, 18(6):1-6.

Zhang, Y.J., & Wu, X.M., et al. (2001). Application and development of membrane distillation. Journal of Filtration & Separation, 11(2):16-21.

Zhong, S.A., Li, Y.P., & Zhou, C.S., et al. (2003). Study of vacuum membrane distillation for polyphenol pharmacy wastewater. *Industrial Water Treatment*, 23(4):44-46.

Zhu, B.K., Xu, Y.Y., & Xiang, H., et al. (1999). Vacuum membrane distillation of polypropylene hollow fiber microporous membrane. Membrane Science and Technology, 19(5):51-54.

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Some Aspects of Tehran's Ecological Footprint

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Abstract

Ecological footprint is a way of measuring urban and regional ecological impacts and guides communities toward sustainability. This Technique measures how much land is required to supply our living and lifestyle including food, housing, energy/fuel, transport, and consumer goods and services along with their corresponding energy requirements.

This study aims to quantify Tehran's ecological impacts through ecological foot prints technique. it suggests that Tehran's metropolitan per capita ecological footprint corresponding with energy in all of the consumption fields is close to 2.9 hectares. This means that taking into consideration the current consumption pattern, Tehran metropolitan require 22 million hectares in order to meet the relevant energy requirements.

Tehran's total per capita ecological footprint is 3.79 hectares. This is corresponded with 28 482 098 hectares .The most conspicuous figure is associated with goods and services sector (2.66). In fact, Tehran's citizens are utilizing nearly 2.5 of their actual share of their ecological capacities and thus abusing their hinterlands.

Keywords: Tehran, Ecological footprint, Service sector, Urban hinterland, Sustainability

1. Introduction

Most changes in the ecosystem are a result of human land-use practices, including agriculture and industrialization. Urbanization is unique in this regard both in terms of the intensity and the extent of its impacts upon natural ecosystems.

Rapid growth of the human population in the twentieth century along with migration into larger cities would intensify the matter.

It is projected that the global urbanization rate will reach 50 percent in 2007, and in 2030 it should reach 60 percent. In other words, the world's population could increase by 2.2 billion people in 2030, with 2.1 billion of these people living in cities**.** *(http://www.gdrc.org/uem/footprints/what-is-ef.html*).

Cities intensively act as centers of human consumption. In fact, major local changes in supply and at the same time drastic increase in consumption level, have allowed societies to overcome regional limits to sustainable consumption levels, and take a risk of depleting other places.

Cities placing further environmental burdens on city hinterlands. They have drawn in energy and matter from all over the ecosphere (Wackernagel and Ress, 1996, 237).

Population growth and changing consumption patterns have increased the demand for resources.

However, sustainable access to natural resources, particularly those related to food, has been a crucial factor in human development throughout history **(**Hopfenberg and Pimentel, 2001; De Vries and Goudsblom, 2002).

Total global consumption of natural resources has risen by fifty percent since 1970; while Earth's natural wealth has decreased by over thirty percent (Living Planet Report, 2000).

In 2002 the biosphere had 11.3 billion hectares of biologically productive area corresponding to roughly one-quarter of the planet's surface (Wackernagel and others,2006).

Biocapacity represents the "endowment" of ecologically productive territory that is locally available and it indicates the local ecosystems potential capacity to provide natural resources and services (Macro Bagliani and others, 2008). This quantity can be compared with the ecological footprint, which provides an estimate of the land area necessary to sustain current levels of resource consumption for a given population.

2. The review of literature

The concept of the 'Ecological Footprint' (EF) was introduced in the early 1990s to more clearly express the possible ecological consequences of human consumption patterns compared to the earth's carrying capacity, (Rees, 1992; Wackernagel and Rees, 1996). The EF is defined as the amount of environmental resources required to support the consumption of a defined population (Detlef and others, 2005).

The measurement units for Footprint accounts are global hectares. They are adjusted hectares that represent the average yield of all bioproductive areas on Earth. More precisely, a global hectare is one hectare of biologically productive space with world average productivity for the given year (Wackernagel and others, 2006).

The global EF covered 13.7 billion ha in 1999, or 2.3 global ha per person (a global hectare is 1 ha of average biological productivity), while the global ecological carrying capacity was only 11.4 billion ha (Bindu and others, 2006).

Knowing ecological foot print of a region then it is possible to define an ecological balance for the territory: its balance is obtained by subtracting from the local population's needs for natural resources (the ecological footprint), the local availability of those resources (biocapacity). A negative balance which is most probable indicates a condition of ecological deficit .Rees argued that this would outline a situation of unsustainability in which the rate of consumption of natural resources is greater than the rate of regeneration by local ecosystems (Rees, 1996).

In 2002, humanity's Ecological Footprint exceeded the Earth's biocapacity by more than 20 percent (Wackernagel and others, 2006)

Thus it is possible to exceed global biocapacity, entering overshoot, because trees can be harvested faster than they re-grow, fisheries can be depleted more rapidly than they restock and CO_2 can be emitted into the atmosphere more quickly than ecosystems can sequester it.

Obviously, the size of a footprint will vary depending on the volume and different types of natural resources consumed by a population, their consumption level which will in turn depend on lifestyle choice, income levels, and technology (*http://www.gdrc.org/uem/footprints/what-is-ef.html*).

If the global population were to consume resources on a level comparable to Western states, an additional two plants would be required. In fact most developed countries have a footprint of over six global hectares (Conorwalsh and others, 2006)

The ecological footprint of an average world citizen is nearly about 2.8 hectares or 6.92 acres. However, the ecological foot print of one average American is 10.3 hectares or 25.45 acres. By contrast, in India the average person uses about 1.98 acres (http://allspecies.org/neigh/nbrfootp.html).

Consumption-land-use matrix regarding ecological foot print has five major consumption categories and six major land use categories. Consumption categories include food, housing, transportation, consumer goods and services.

The land is divided into 6 categories: (1) cropland; (2) grazing; (3) forest; (4) fishing ground; (5) built-up land; (6) energy land.

In calculating the ecological footprint, conversion factors are of great relevance: they allow translating a local population consumption of goods and services into the corresponding area of land that is directly or indirectly used for their production (Macro Bagliani and others, 2008).

In order to convert to area figures, the national consumption values (in terms of tones of oil equivalent) were converted to units of energy**(**Conorwalsh and others, 2006).Wackernagel and Rees in fact provided different ideas on which the conversion of CO_2 emissions to equivalent land area could be based, in particular (1) the forest area required for sequestering the CO_2 and (2) the area needed for producing the same amount of fossil-fuel-based energy by biofuels (wackernager& REES,1996).

Based on these prominent ecological facts associated with ecological foot print from one hand, and Tehran's present urbanization rate (1.4) and its subsequent consumption level and Tehran's area (733 square km) on the other hand, determination of Tehran's ecological footprint in the area of food, housing, consumer goods and services and transportation receive considerable attention. This requires calculation of different land uses along with their corresponding energy usages.

3. Calculation of Tehran's Ecological Footprint

Calculation of Tehran's Ecological Footprint requires the list of land uses along with their corresponding areas (Table 1).

This table suggests that the most dominant land use is associated with the service sector. This is followed by residential land use with 171 square km which comprised 25.7% of the total. Agricultural lands, horticulture, and those under dairy activities turned out to be near 60 square km. This is followed by non-built areas which comprised close to 50 square km.

Calculation of ecological footprint requires determination of the amount of energy consumption in each consumption field including transportation, consumer goods, agriculture, housing and services taking into consideration corresponding type of energy (Table 2).

As the table suggests service sector with energy consumption of 107 552 milliards MJ is the greatest user (organization of Iran's petroleum products, 2005). Wackernagel and Rees suggest that on average 1 hectare of forest can sequester the co_2 emissions generated by the consumption of 100 GJ of fossil fuel each year (Bicknell and others, 1998).

This would intensify the magnitude of the problem associated with the required energy land in this sector.

Table 3 shows Tehran's metropolitan per capita ecological footprint in the area of energy consumption in each sector.

As the table suggests, service sector with 1.43 hectares per capita ecological footprint is on the top of the list. Same thing would almost apply to the area of consumption goods (1.22). Tehran metropolitan's per capita ecological footprint corresponding with energy in all of the consumption fields is close to 2.9 hectares. This means that taking into consideration the current consumption pattern, Tehran metropolitan require 22 million hectares (294 times of its present area) in order to meet their needs.

As a matter of fact Cities placing further environmental burdens on city hinterlands. They have drawn in energy and matter from all over the ecosphere (Wackernagel and Ress, 1996a: 237).

Ecologically speaking, Tehran puts its steps on vast areas including Gilan, Mazandaran, Semnen, Isfahan and Chaharmahal in order to meet its needs (map 1).

Table 4 shows the amount of Tehran's deficit energy land in different sectors.

Wackernagel and Rees in fact provided different ideas on which the conversion of CO_2 emissions to equivalent land area could be based, in particular (1) the forest area required for sequestering the CO_2 and (2) the area needed for producing the same amount of fossil-fuel-based energy by biofuels (Wackernagel and Rees,1996).

This table suggests that Tehran's total ecological lands pertaining to service sector is close to 11million hectares. This is followed by Tehran's total ecological lands in the area of consumer goods (9 millions hectares)

Thus the deficit energy land associated with service sector is the highest (146 times of Tehran's present area). In general, Tehran needs 293 of its present area in order to meet all of the required energy in the area of transportation, consumer goods, agriculture, residential, and services.

3.1 Tehran's ecological footprint in the area of food

The most dominant food items of Tehran's citizens in the area of plant is wheat, grains, vegetable, fruits, oil and shortening, and sugar with per capita consumption of 1.50 Kg. Per capita animal consumption of animal products is 1.78 Kg.

However, energy consumption relating to agricultural section was 230906 MJ .That is per capita energy consumption in this area turned out to be 30.787 MJ.

Matrix associated with Tehran's metropolitan ecological foot print in food sector consumption which contains energy land(Note 1), crop lands, grazing land, fishing ground, built-up lands in area unit per person shows interesting results (table 5).

Tehran's per capita ecological footprint pertaining to food in general is 0.91 hectare. It means that the total land needed to meet Tehran's needs taking into consideration their present consumption and production patterns are 6790791 hectares. That is Tehran needs 93 times of its present area in order to meet its needs.

3.2 Per capita ecological footprint in the area of consumer goods and services

According to this study the total amount of energy consumption in the area of consumer goods and services is 912 million GJ. Its corresponding per capita energy consumption is 122 and 143 millions GJ respectively (Fao Statistcs,2005). Taking into consideration that each 100 GJ energy associates with one hectare of ecological lands, per capita ecological footprint are amounted to be 1.22 and 1.43 hectares respectively. That means that meeting Tehran's needs in this area require 125 times of its present area which is drained from Tehran's hinterlands. Tehran's

consumption level in the area of wood consumption is associated with 0.1 hectare of forest per person. In effect, total ecological footprint in the area of consumer goods and services is around 2.66 hectares which is the greatest comparing with the other areas and fields.

That is if Tehran's citizen is to keep their present consumption and production levels, Tehran needs 273 times of its present area.

3.3 Tehran's ecological footprint in the area of housing

Residential sector is occupying 171 millions square meters. Per capita energy consumption associated with this sector is over 2 million MJ. However, as already mentioned each hectare of land is associated with 100 GJ of energy. Per capita ecological footprint pertaining to housing sector is 0.22 hectare. That is, Tehran needs 1 696 042 hectares of land in order to meet its needs in this field which is 23 times of its present area.

3.4 Ecological foot print in the area of transportation

The amount of energy associated with transportation is over 1 212 682 486 MJ. It has been argued that the types of consumption that most contribute to the energy component of the ecological footprint are transportation (1.23 global hectare, gha, per capita)(Macro Bagliani and others, 2008**).** Tehran's per capita energy consumption in this area is over 16 millions MJ. Knowing the fact that each ha is associated with 100 GJ, so that its per capita ecological footprint would be 0.0016 hectare. Thus, Tehran's present population is utilizing 12.127 hectares in order to meet its energy requirements in the area of transportation (organization of atomic products, National Gas Company 2005).

Taking into consideration Tehran's approximate coverage under transportation (160 000 000square meters), and its population, per capita ecological footprint in the area of transportation turned out to be 0.0038 hectare. In other word, Tehran needs over 28 million hectares in order to meet its needs in the area of transportation.

3.5 Total Tehran's Ecological Footprint

Ecological footprint shows the relationship between different sectors including food stuffs, housing, transportation, consumer goods and services; and the amount of needed lands associated with each sector. Interestingly enough, the land needed for housing not only include the lot itself, but also all associated lands pertaining to provision of utilities as well as lands linked with construction materials. Table 5 shows associated needed lands in different sectors pertaining to Tehran's ecological footprint.

Columns 1,2,3,4,5,and 6 indicate the energy lands , the agricultural lands , grazing land for production of dairy products, and meat, built areas and infertile lands, and the needed fishing ground to support the population's sea foods associated with each corresponding sector.

This table suggests that Tehran's total per capita ecological footprint is 3.79 hectares. This is corresponded with 28 482 098 out of this the most prominent figure is associated with consumer goods and service sector (2.66). Deficiency in terms of provision of goods and services is greatest (272 times of its present area). This is followed by deficiency in the area of food stuff (92 times of its present area).

4. Conclusion

The concept of an "ecological footprint" the amount of land required to produce the resources needed by one person, attempts to quantify humanity's impact on nature. This has received considerable attention as a useful indicator in the context of sustainable development. Tehran's per capita ecological footprint is amounted to be 3.79 hectares. However, Tehran's per capita ecological footprint is not identical in each field. Tehran's per capita ecological footprint in the area of animal and plant food, goods and services, housing, and transportation is 0.91, 2.66, 0.22 and 0.0038 hectare respectively. Taking into account the country's ecological footprint, 2.42, Each Tehran's citizen is putting her steps on 1.37 hectares of its hinterlands. Comparing with world per capita ecological footprint (1.5), Tehran's ecological footprint is 2.29 larger. This means that each Tehran's citizen is utilizing nearly 2.5 times of its actual share. This in turn, has led to instability of Tehran as well as its hinterlands. In fact, with humanity's current demand on nature overshoot is no longer merely a local but, rather, a global phenomenon. Long run economic welfare depends upon meeting the criteria of strong sustainability. This resource accounting tool can assist local governments in managing their ecological assets, and support their sustainability efforts.

References

Bagliani,a,b, M., , Gallic, A., Niccoluccic, V., & Marchettinic, N. (2006). ecological footprint analysis applied to a sub-national area: the case of the province of Siena (Italy), journal of environmental management: ecological footprint analysis page 1 of 28.

Ball, J. R., Bicknell, B. K., Bigsby, R. H., &Cullen, R. (Nov 1998). New Methodology for the Ecological Footprint with an application to the New Zealand Economy, Ecological Economics, volume 27,Issue 2, ,pages 149-160

Boom Sazaun consultant Engineer, 2006.

De Vries, H.J.M., Goudsblom J. (2002). Mappae Mundi - Humans and their habitats in a socio-ecological perspective: Myths, maps, methods and models. Amsterdam University Press

Du, B., Zhang, K., Song G., & Wen, Z. (2006). Methodology for an Urban Ecological Footprint to Evaluate Sustainable Development in China, international journal of sustainable development & world ecology 13, 245-254.

Hopfenberg, R., Pimentel, D. (2001). human population numbers as a function of food supply, environment, development and sustainability 3, 1-15.

Kraft, M., Is Your Neighborhood Sustainable? http://www.allspecies.org/neigh/nbrfootp.htm

Organization of atomic products, (2005). National Gas company.

Rees, W. E. (1996). Revisiting carrying capacity: area-based indicators of sustainability, population and environment Volume 17, 3, pp. 195-215.

Ress, W. E. (1992). ecoligical footprint and appropriated carrying capacity: what urban economics leave out, environment and urbanization 4 (2), 120-130, 1992.

Tehran's distribution organization of petroleum products, 2005

Urban Environmental Governance, for sustainable development in Asia and the pacific: A regional overview (2005), United Nations Publication, http://www.gdrc.org/uem/footprints/wat-is-ef/html

Vuuren, D, P.van, Bouwman, L, F. (2005). Exploring past and future changes in the ecological footprint for world regions,Ecological Economics 52,43-62

Wackernagel, M, Kitzes, J, Moran, D, Goldfinger S,, & Thomas, M. (2006). The ecological footprint of cities and regions: comparing resource availability with resource demand, Environment and Urbanization, Volume 18, 103.

Wackernagel, M., & Rees, W. (1996). urban ecological footprints: why cities cannot be sustainable-and why they are a key to sustainability, environmental impact assessment review, 16(4-6), 223-248.

Wackernagle, M., Ress, W. E. (1995). our ecological footprint: reducing human impact on the earth, Gabriola Island, British Columbia, Canada, New Society Publishers.

Walsh, C, McLoone A, O'Regan, B, Moles R, & Curry Robin. (2006). The application of the ecological footprint in two Irish urban areas: Limerick and Belfast, Irish geography, volume 39 (1), 1-21, 2006.

WWF, UNEP-WCMC. (2000). living planet report, world wildlife, found editor.

Note 1.

The land area corresponding to fossil fuel consumption can represented as the productive land necessary to produce the equivalent amount of energy

Table 1. Tehran's land uses

	Type of land uses	Area	%	Per-capita
1	Residential	171 215 356	25.7	23.1
2	Commercial	14 972 236	2.3	0.2
3	Education	6 956 236	1	0.9
4	Higher education	9 824 875	1.5	1.3
5	Religious	2 327 530	0.3	0.3
6	Cultural	2 568 414	0.4	0.3
7	Tourism	647 899	0.1	0.1
8	Medical	3 824 606	0.6	0.5
9	Recreational	1 646 122	0.2	0.2
10	Sport	8 400 939	1.3	1.1
11	Administrative	9 790 210	1.5	1.3
12	Green space	61 492 474	9.2	8.3
13	Military	56 368 359	8.5	7.6
14	Industrial	38 175 996	5.7	5.1
15	Infrastructure	5 786 145	0.9	0.8
16	Transportation	31 912 092	4.8	4.3
17	Non- built	47 726 813	7.2	6.4
18	Reads & pavement	132 224 315	19.9	17.8
19	Social & public services	972 590	0.1	0.1
20	Ravines	5 737 799	0.9	0.8
21	Agriculture	19 104 118	2.9	2.6
22	Horticulture	19 510 118	2.9	0.2
23	Dairy	19 510 324	0.2	1.7
24	Others	1 212 566	1.9	4.7
Total		665 297 395	100	89.7

Source: Boom Sazaun consultant Engineer, 2006, p.116

Table 2. energy consumption in MJ

	Total	Electricity	Natural Gas	Fuel oil	Gasoil	kerosene	Gasoline
Transportation	121 268 248 617	4 599 853	5 240 998 000	0	6 236 764	0	116 016 414 000
Consumer goods	91 161 895 707 416	1 336 079	1 379 210 000 000	89 683 576 560 000	1 001 673	99 106 809 664	0
Agriculture	230 905 634 538	1 113 239	0	221 203 829 056	556 851	9 700 135 392	0
Housing	16 037 920 627 712	29 148 509	292 313 708 000	0	2 184 547	15 745 575 586 656	0
Services	107 551 990 218 282	16 560 000	47 287 200 000	1 230 170 107 008	283 695	1 954 831 153 960	1 520 905 000
Total	215 103 980 436 565	52 757 680	1 724 051 906 000	91 134 950 496 064	10 263 530	17 809 213 685 672	117 537 319 000

Source: Tehran's distribution organization of petroleum products, 2005

Table 3. Per capita Tehran's ecological footprint pertains to energy consumption in hectare

Sector	Per capita ecological footprint
Transportation	0.00
Consumer goods	1.22
Agriculture	0.00
Housing	0.21
Services	1.43
Total	2.87

Source: Authors computation

Table 4. Tehran's deficit energy land

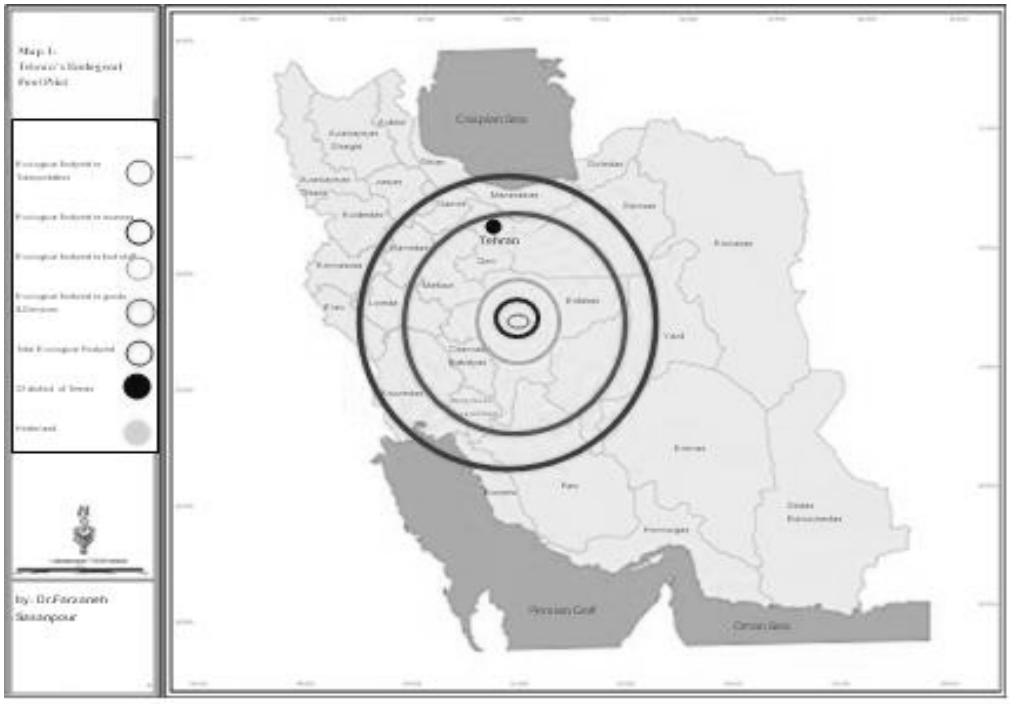
Sector	Per capita ecological footprint	Tehran's ecological lands (ha)	Tehran's deficit energy land (ha)
Transportation	0.001616910	12126.82486	0.165440994
Consumer goods	1.215494943	9116189.571	124.368207
Agriculture	0.003078742	23090.56345	0.315014508
Housing	0.213838942	1603792.063	21.87983715
Services	1.434026536	10755199.02	146.7284996
Total	2.868053072	21510398.04	293.4569992

Source: Authors computation

Table 5. food, land uses matrix corresponding with ecological footprint

Land use consumption	Energy land	Agriculture	Grazing land	Forest	Built land	Fishing ground	Total E.F	Total needed land (ha)	Deficit land (ha)
Food stuff	0.003078742	6.40	0.1	0	0.00172	0.8	0.90543874	6790790.565	92.64380034
Plant food stuff	0	0.00048	0	0	0.001501429	0	0.00198143	14860.7175	0.202738302
Animal food stuff	0	0.00016	0	0	0.000217792	0	0.00037779	2833.44	0.038655389
Housing	0.213838942	0	0	0/01	0.0023	0	0.226138942	1696042.065	23.13836378
Under construction	0	0	0	0	0.000009	0	0.000009	67.5	0.000920873
Transportation	0.00161691	0	0	0	2.20	0	0.00381691	28626.825	0.390543315
Surface transportation	0	0	0	0	0.001388716	0	0.001388716	10415.37	0.14209236
Rail road	0	0	0	0	0	0	0.00	0	0
Aviation	0	0	0	0	0.000132053	0	0.000132053	990.3975	0.013511562
Infrastructure	0	0	0	0	0.0	0	0.00	0	0
Goods & services	2.649518479	0	0	0.01	0.0027	0	2.662218479	1966638.59	272.3961609
Total	2.868053073	6.40	0.1	0.02	8.92	0.8	3.797613073	28482098.05	388.5688683

Source: Authors computation



Map 1. Ecological footprint of Tehran's metropolitan

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Sustainable Management of a Matured Oil Palm Plantation in UPM Campus, Malaysia Using Airborne Remote Sensing

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Abstract

Accurate and reliable near-real time information is needed for a sustainable oil palm plantation management, especially on plant quality and health. Airborne remote sensing provides the effective recent agricultural crop information for the oil palm plantation industry planning, management and sustainable development. A study on the characteristic of a matured oil palm plantation in UPM campus was conducted using airborne hyperspectral remote sensing technique. Airborne hyperspectral remote sensing can be used as an effective tool in monitoring the characteristic of oil palm plantation in order to predict and manage the oil palm production. The general objective of this study is to assess the capability and usefulness of UPM-APSB's AISA airborne hyperspectral sensor to determine the characteristic of a matured oil palm plantation for its sustainable development while the specific objective is to identify, classify and produce the thematic map of matured oil palm plantation in the study site. The age of the oil palm plantation used in this study is 27 years old. Sobel filtering was used to enhance the image. Spectral Angle Mapper (SAM) analysis was then used to classify the characteristic of the plantation within the study area. A thematic map of 27 years old matured oil palm plantation was produced and the characteristic of the oil palm plantation in the study site was identified as 173 healthy, 7 dead, 9 stressed oil palm trees and open areas in the plantation with a mapping accuracy of 93.33%. This has shown that UPM-APSB's AISA airborne hyperspectral sensor is capable of mapping a matured oil palm plantation with such characteristics for its sustainable management and future development.

Keywords: Oil palm, Precision, Sustainable production, Individual tree, Plantation characteristics

1. Introduction

In Asia, the main oil palm producing countries are Malaysia; the Malaysian oil palm industry recorded an impressive performance in 2006. The total oil palm planted areas in 2006 were 4.17 million ha. While, the total exports of oil palm products were 20.13 million tonnes in 2006. This scenario trigger the export earnings of oil palm products rose to a record RM 31.8 billion in 2006. The industry also saw exciting developments shaping up in the local bio-fuel industry with the Honourable Prime Minister of Malaysia launching the "Envo Diesel" (palm olein blend with diesel) (http://www.econ.mpob.gov.my/economy/EID Review06.htm). Due to the importance of oil palm to the country, accurate and reliable information is needed for oil palm plantation management, especially on plant quality, phenology, health and yield prediction. However, in the context of Malaysia, lack of data, cost effective and timely processing of information for oil palm management planning are major constraints, which hold up decision-making. Currently data collection for oil palm planning and management depend mainly on traditional methods of sample surveys in the field. The main task of Malaysian agriculture agencies is to improve the reliability, timeliness and cost effectiveness of data collection techniques. Remote sensing was identified as effective recent agricultural crop information for the global oil palm plantation industry planning (http://www.gisdevelopment.net/aars/acrs/2000/ps3/ps302.asp).

Monitoring characteristics of oil palm plantation is beneficial and important for oil palm planters as reported by McMorrow (1995), Lukman & Poeloengan (1996) and Ibrahim *et al*. (2000). The use of airborne hyperspectral imaging system to accomplish this task is making the job easier and fast. Airborne hyperspectral imaging is only one of many remote sensing tools available to oil palm managers, but it offers the most comprehensive perspective of all. Airborne hyperspectral imaging system can provide accurate vegetation map quickly and cost effectively. The data are capable of providing repetitive and continuous information on different scales. Apart from this, airborne hyperspectral imaging

system could provide cost competitive, quick information and "real time" data on oil palm plantation than satellite remote sensed data. Currently, data collection for oil palm planning and management depend mainly on traditional methods of sample surveys in the field. Identifying the characteristics of oil palm plantation using this traditional method is acquire a relatively time consuming and high expenditure. While satellite based sensing technique are limited, unsuitable and ineffective because of lower resolution, resulting inaccurate and non-detail data about their characteristics in the plantation. Supervising physical condition of oil palm plantation using real time information is essential for monitoring disease or pest outbreaks in order to predict and manage oil palm production. Airborne hyperspectral imaging system can provide real time and high spatial resolution data for identifying characteristic of oil palm plantation. Airborne hyperspectral imaging system has significant potential to aid oil palm monitoring and detection efforts. It also provides a cost-effective method to map oil palm and at the same time provides site-specific assessments of management practices and growth performance of the palms.

The general objective of this study is to assess the capability and usefulness of UPM-APSB's Airborne Imaging Spectrometer for Application (AISA) sensor to determine the characteristic of a matured oil palm plantation. The specific objective is to identify, classify and produce the thematic map of such plantation for its future sustainable palm oil production by an individual tree basis.

2. Methodology

2.1 Description of study area

The study area is located in main campus of Universiti Putra Malaysia (UPM), Serdang, Selangor, Malaysia. It is located approximately 23 km from the south of Kuala Lumpur and 16 km north of Putrajaya (Latitude N 1° 24' to N 2° 32' and Longitude E 102° 42' to E 103° 38'). UPM campus area covers about 1,214 ha and 121 ha are used for administration buildings, faculties, lecture hall, student's dormitories, staff housing and recreation field. The rest of the area is currently cultivated with many crops that include oil palm, rubber tree, orchards and pasture. A significant portion of the farm is utilized as share-farm by the students for their practical and research work and also by the academic staffs for their research programs. The oil palm plantation used in this study is located at latitude N 2° 59' 15.73" – N 2° 59' 11.70" and longitude E 101° 43' 21.51" – E 101° 43' 25.66". The age of the oil palm plantation in the study site is 27 years old.

2.2 Equipments and software

UPM-APSB's AISA airborne hyperspectral sensor is designed to collect accurate and reliable information of the earth surface. UPM-APSB's AISA hyperspectral systems is a complete, pushbroom imaging systems, consisting of a hyperspectral sensor head, a miniature GPS/INS sensor, and a data acquisition unit in a rugged PC. The system is designed to be user and field friendly. It is quick to install and remove from any aircraft even the lightest ones, and they provide timely, accurate and reliable information. The system includes an in-flight configuration setting, which allows alterations to be made easily for each exercise. UPM-APSB's AISA sensor is also the best mix of economy and performance depending on the application requirements. The total system weight is less than 15 kg (ca.35 lbs) from which the front-end weighs only 4 kg (9 lbs). Global Positioning System (GPS) was used to determine the position of the oil palm tree in oil palm plantation. It was used during the ground truth to compare the data taken by the UPM-APSB's AISA sensor with the ground data. The Environment for Visualizing Images (ENVI) software was used to process the raw hyperspectral data including the radiometric correction, band combination, image enhancement and other basic image processing system for data analyzing. This is because ENVI software package is an easy-to-use remote sensing image analysis and GIS data integration and offers a robust suite of spectral identification and exploitation tools in the industry.

2.3 Methodology

Image data was obtained by UPM-APSB's AISA airborne hyperspectral sensor, an airborne imaging spectrometer. The sensor was flown at an altitude of 1000 m from the ground at a spatial resolution of 1 m. The aircraft flying speed was 120 knots (60 ms^{-1}). These images were used for mapping of matured oil palm plantation of the study site. The entire digital image capturing process was taken by the Aeroscan Precision (M) Sendirian Berhad (APSB) which is located at the Forest Geospatial Information and Survey Lab, Lebuh Silikon, UPM. Figure 1 shows the raw image of matured oil palm plantation of the study site with band R19 G11 B2.

<<Fig. 1. Raw image of matured oil palm plantation of the study site (Band – R19 G11 B2)>>

Prior to data analysis, initial pre-processing on the raw data was usually carried out to correct for any distortion due to the characteristics of the imaging system and imaging conditions. These procedures include radiometric correction to correct for uneven sensor response over the whole image and geometric correction to correct for geometric distortion due to Earth's rotation and other imaging conditions (such as oblique viewing). The image was also transformed to conform to a specific map projection system. Image Enhancement operations are carried out to improve the interpretability of the image by increasing apparent contrast among various features in the scene. There is no ideal or

best image enhancement because the result are ultimately evaluated by humans, who make subjective judgements as to whether a given image enhancement is useful (Jensen, 1996). The enhancement techniques depend upon two factors mainly, the digital data (i.e. with spectral bands and resolution) and the objectives of interpretation. As an image enhancement technique often drastically alters the original numeric data, it is normally used only for visual (manual) interpretation and not for further numeric analysis. Contrast enhancement was performed to change the range of values in the image to increase its contrast. This process expands the original input brightness values to make use of the total range of the output device and thus increase the quality of te processed image. Different sets of band combinations was displayed to create a different composite effects and increased information on oil palm plantation cover and its characteristics. Image Classification based on their reflectance was also performed using the supervised classification Spectral Angle Mapper (SAM) algorithm. Redundant bands were removed before classification took place.

Ground verification was performed to verify and match the characteristics of features in the image that have been retrieved from the airborne hyperspectral images. Ground verification was carried out by taking the exact location of the physical condition in the oil palm plantation to assess the accuracy between the UPM-APSB's AISA DGPS and also the ground GPS. Photographs were taken and parameters related to physical condition of oil palm plantation to this study were recorded. The data was also collected in the form of latitude and longitude of the position of the features present in the oil palm plantation using GPS. A total of 15 sample points were chosen randomly and visited during ground verification work. These 150 sample points were used to verify the accuracy percentage of the study. All the data recorded were then matched with the data taken by the airborne on-board DGPS. All collected data obtained from the ground verification were used to determine the accuracy of mapping in this study. Ground verification points based on the GPS readings were prepared earlier according to the processed image. Data obtain from ground verification were closely related to the accuracy assessment. This process is needed to ensure that the classification has been done was precise as to the real condition on the ground. In this study, accuracy assessment was carried out by using 150 sample points which were chosen randomly from the image. The sample points were checked on the ground to make sure they matched with the parameters recorded in the image to calculate the mapping accuracy percentage in this study.

3. Results and discussion

Selecting appropriate bands to be used to create a useful and attractive image is very essential for making enhanced colour composite image which is suitable for interpreting land cover pattern. In this study, band 10, 16, 8 (RGB) with sharpening enhancement were selected to be the best combination and to get the sharpest image for further processing. It was used for further analysis in image classification since it provides a well enhanced colour composite image with respect to the oil palm cover. Bright red areas on the image (Figure 1) represent high near-infrared reflectance, usually corresponding to healthy vegetation. In this study, Sobel filter was found to be the most suitable filter to be applied to the airborne hyperspectral imagery especially for visual interpretation of vegetation on the image. The Sobel filter is a non-linear edge enhancement, special case filter that uses an approximation of the true Sobel function, and is a preset 3 x 3, non-linear edge enhancement operator. The size of the filter cannot be changed and no kernel editing is possible. Figure 2 showed the enhanced image with Sobel Filter that came out to be the best filter for this study.

<<Fig.1. Raw image of matured oil palm plantation of the study site (Band – R19 G11 B2)>>

<<Fig.2. Image after enhancement (Sobel 75%)

R10G16B8 (band combination) >>

Figure 3 showed the spectral signatures derived from the UPM-APSB's AISA airborne data for the oil palm trees that are available in this study site. It can be clearly seen that oil palm tree has its own unique spectral reflectance that made it possible to be differentiated from others. The area of oil palm plantation can be easily distinguished from other land areas with its green colour reflectance occurring in the middle of the whole image.

<<Fig.3 Spectral signatures of a matured oil palm plantation in UPM Campus>>

The image clearly differentiated the individual oil palm trees from the other features such as healthy oil palm tree (green), stressed oil palm tree (red), dead oil palm tree (blue) and open area or canopy gaps (white) after SAM was applied to the image. The algorithm determines the spectral similarity between two spectra by calculating the angle between the spectra, treating them as vector in a space with dimensionality equal to the number of bands.

Spectral reflectance of the matured oil palm plantation in the sample plot area was selected randomly from the image to check the curve of spectral reflectance. This step was done to confirm that the classes that have been map out belonged to the respective classes. Figures 4a-4c showed that the various spectral reflectances of the sampled healthy, dead, vs. stressed oil palm trees and open area in the plantation,

<<Figs. 4a-4c. Spectral signatures of stressed, healthy and dead oil palm individual trees>>

Based on the image and the spectral reflectance signatures in Figures 4a-4c, it can be seen that every single class of the matured oil palm plantation have their own unique spectral signature. These subtle differences were used to classify the

physical characteristic of the oil palm plantation. The open area class showed a different reflectance signature pattern within a range of 450 – 700 nm due to the different intensity of the grass cover over some parts of the open areas. The healthy oil palm trees have higher reflectance between the frequency ranges of 700-900 nm. This is due to the higher chlorophyll concentration in the fronds of healthy trees. Higher chlorophyll concentration will produce shiny cuticle on leaves surface, which led to the increasing reflectance on leaves. Hence, our eyes observe healthy vegetation as green in color because of the very high absorption of blue and red energy by plant leaves and the high reflection of green energy. A similar study by Ourcival (1999) and McMorrow (1995) reported that the palm's development factor such as leaf age and plant species may cause dissimilar reflectance spectra.

Meanwhile, the "stressed" or diseased infected trees seem to have a lower level of chlorophyll and mineral deficiency compared to the healthier palms. Iron, magnesium, nitrogen and sunlight are necessary for chlorophyll production. Lacking in any one of these can lead to yellowing of the oil palm fronds which may lead to the decrease in the spectral reflectance of the leaves within a range of 450 – 5 00 nm. Dead oil palm trees have the lowest spectral reflectance probably due to its lowest moisture content that least absorbs the reflectance energy in the infrared portion of the electromagnetic spectrum and at the same time decreases its reflectance. The stressed tree recorded during ground verification was probably caused by the lightning strikes. Oil palm trees have less resistance to lightning because of the sap and water inside it are better conductors than air. Some of the oil palm trees may suffer a light damage from a lightning strike while others may go completely harmed depending on the intensity of the lightning.

Results of the ground verification data showed that 140 parameters of oil palm plantation confirm available on the ground compared to 150 parameters in the image. The mapping accuracy for this study is 93.33% as calculated below:

$$140/150 * 100\% = 93.33\%$$

However, the misclassified parameter was the dead oil palm trees which had been misclassified as the open area due to their short residual stump.

The availability of 1 m spatial resolution airborne hyperspectral imaging system provides better alternatives for individual oil palm tree counting. Counting trees in an image is much more manageable as workers can label the trees easily on the image. From the sample image in Figure 5, 173 healthy oil palm trees, 9 stressed oil palm trees and 7 dead oil palm trees were detected for the whole study area. Finally, the output thematic map of matured oil palm plantation) was produced as shown in Figure 6. The green colour represents the healthy oil palm trees, red represent the stressed oil palm trees, blue colour represent the dead oil palm trees while black represent unclassified areas. This geospatial map is useful in planning and managing the oil palm plantation. With an airborne hyperspectral data, identifying the characteristics of oil palm plantation will be cost-effective and time-efficient.

<<Fig.6. Thematic Map of Matured Oil Palm Plantation>>

4. Conclusions

A thematic map of a matured oil palm plantation was developed from airborne hyperspectral imaging system to further plan for its sustainable management and palm oil production. It can be used to identify the characteristics of the oil palm plantation. This information will definitely aid the management of the oil palm industry in UPM Campus and elsewhere. The UPM-APSB's AISA airborne sensor is capable and useful for determining the characteristic of matured oil palm plantation such as healthy oil palm tree, dead oil palm tree, stressed oil palm tree and open area in the plantation with mapping accuracy of 93.33%. The characteristics of the plantation under study indicated that there are 173 healthy, nine "stressed" and seven dead oil palm trees. Future research should be focused on identifying pest and disease infested individual oil palm trees using airborne hyperspectral imaging system.

References

http://www.econ.mpob.gov.my/economy/eid_review06.htm (2006). Overview of The Malaysian Oil Palm Industry 2006.

http://www.econ.mpob.gov.my/economy/EID_Review06.htm.

http://www.gisdevelopment.net/aars/acrs/2000/ps3/ps302.asp

Ibrahim, S., Zainal Abidin Hasan and Mariamni Khalid. (2000). Application of Optical Remote Sensing Technology for Oil Palm Management. Proceedings of The 21st Asian Conference on Remote Sensing. 4-8 December 2000, Taipei, Taiwan. 3 p.

Jensen, J.R. (1996). Introductory Digital Image Processing: A Remote Sensing Perspective, 2nd Edition. NJ: Prentice-Hall.

Lukman, F.M., and Z. Poeloengan. (1996). Application of Remote Sensing Technique for Oil Palm Plantation Management. Proceedings of the 1997 PORIM International Palm Oil Congress "Competitiveness for the 21st Century". p. 460-467.

McMorrow, J.M. (1995). Relation of Oil Palm Spectral Response to Stand Age. Int. J. Remote Sensing, 16: 3203-3209.

Ourcival, J. M., R. Joffre and S. Rambal. (1999). Exploring the Relationship Between Reflectance and Anatomical and Biochemical Properties in Quercas ilex leaves. New Phytol. 143:351-364pp.

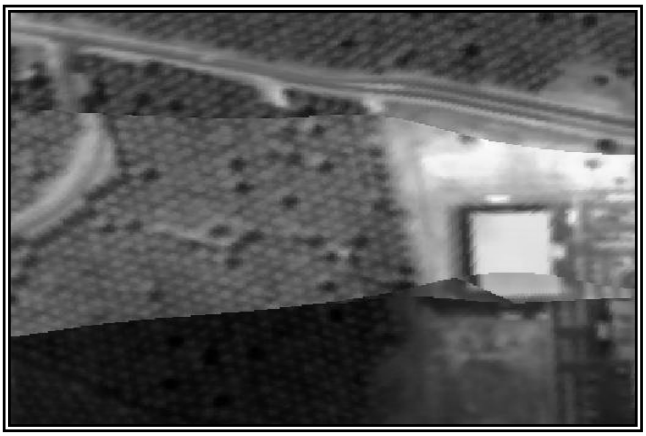

Figure 1. Raw image of matured oil palm plantation of the study site (Band – R19 G11 B2)

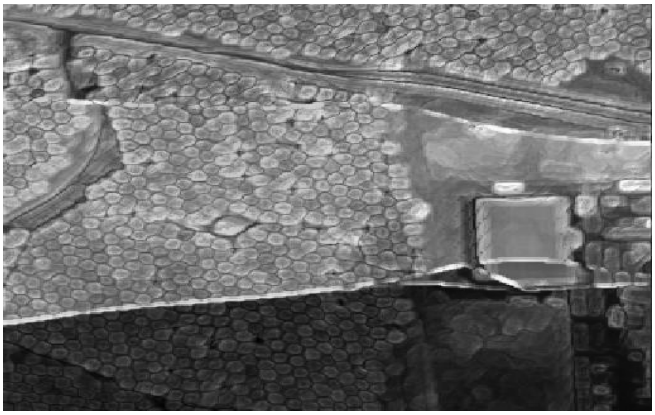

Figure 2. Image after enhancement (Sobel 75%) R10G16B8 (band combination)

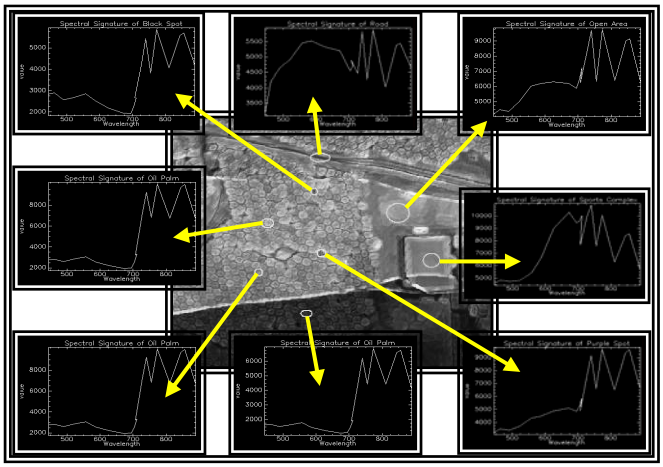

Figure 3. Spectral signatures of a matured oil palm plantation in UPM Campus

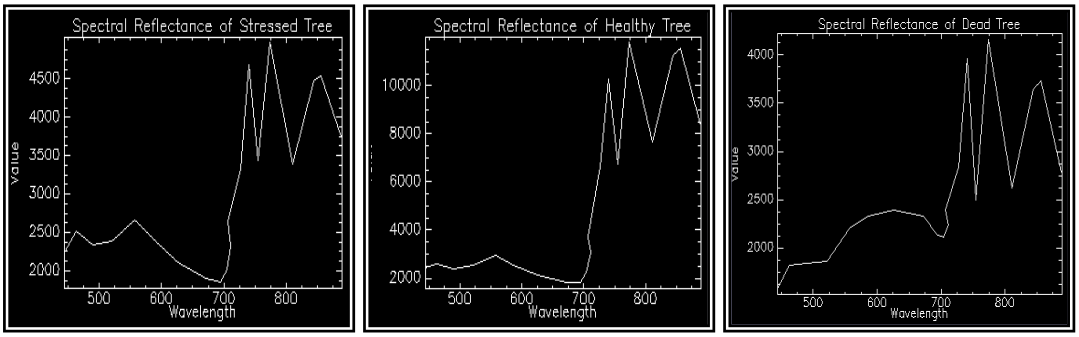

Figure 4a-4c. Spectral signatures of stressed, healthy and dead oil palm individual trees

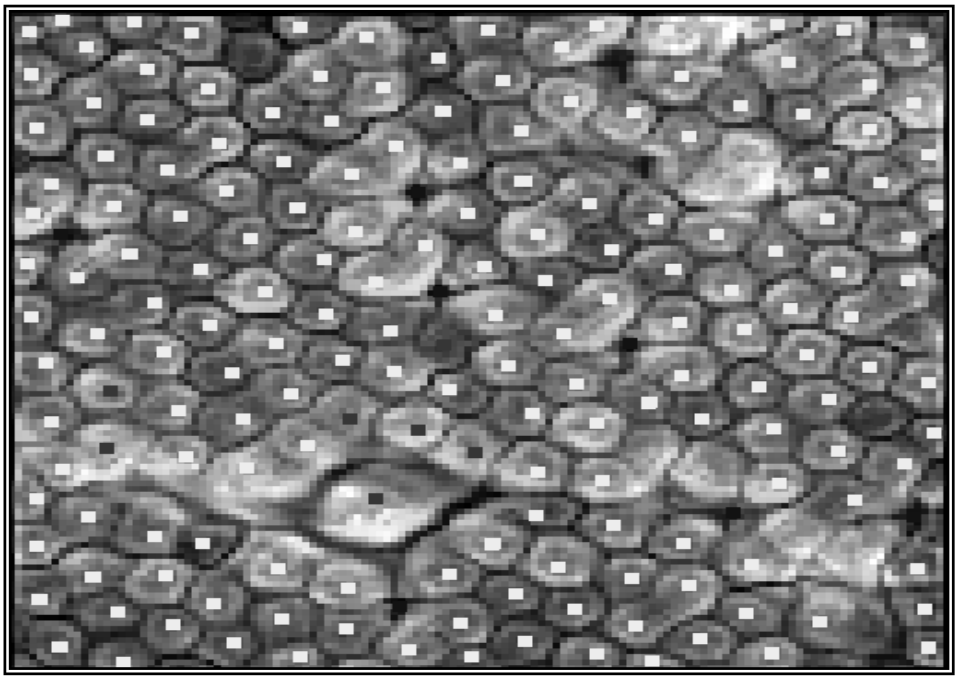

Figure 5. The airborne image showing an individual oil palm tree counting capability

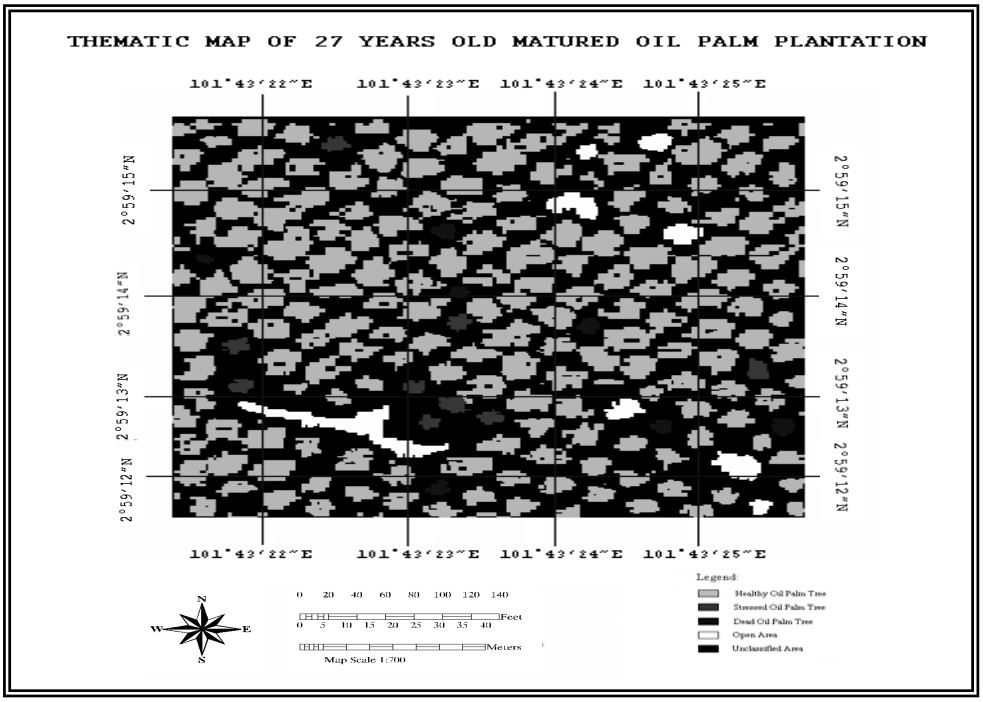

Figure 6. Thematic map of matured oil palm plantation

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Food Preferences of Seladang (Bos gaurus hubbackki) in Ulu Lepar, Pahang, Peninsular Malaysia

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Abstract

Seladang food preferences primarily depended on the habitat types within their home range. Shrubs and grasses were their main food sources. The types of food species preferred by seladang in each habitat types were unknown. In this study, the food species were identified and classified according to the intensity of browsing and grazing capacity of seladang within each habitat type such as in the primary forests, secondary forests and agricultural areas. Study plots and sub-plots were selected based on feeding habit and footprint signs. The results of this study found that 17 species of shrubs and 6 species of grasses were preferred by seladang. *S. acuminata* (7.95%) was the most preferable species of shrubs in the primary forest, *Melastoma malabathricum* (10.42%) in the secondary forest and *Erythrina variegata* (18.56%) in the agriculture area. The amount of grass species eaten by seladang is not significantly different but *Imperata cylindrica* was grazed in the primary forest compared to *Paspalum conjugatum* in the secondary forest and *Paspalum vaginatum* in agricultural area.

Keywords: Seladang, Food preferences, Shrubs, Grasses

1. Introduction

Habitat is defined as an area where an organism lives and meets its basic needs for food, water, cover and space to survive. Each species of wildlife has different habitat requirements.

Wildlife habitat plays a vital role in the ecological and biological processes that are essential to life itself. The functioning of the biosphere, and hence the maintenance and enhancement of human life, depends on countless interactions among plants, animals and micro-organisms.

Wildlife habitat regardless of whether it is terrestrial, marine or wetland habitats, is significant because of a number of functions it performs to support wildlife. These include (a) food for browsing (the twigs and buds of shrubs and trees), and foraging (grasses and legumes); (b) water that they need directly from the food they eat; (c) cover to protect themselves from predators, resting, rearing their young and protection against inclement weather and (d) Space for a territory or home range of the year.

Several investigators have used subjective methods to classify the extent of browse utilization by wildlife species. Robert and Gary (1997) reviewed the methodologies used to estimate browsing frequencies of wildlife species. Frequently, browsing plants were estimated as: (1) no browsing to light browsing; (2) moderate and (3) severe. While others used of -H- to designate heavy browsing (50-100 percent of a plant showing evidence of utilization), -M- for moderate (10-50 percent of plant utilized) and "L" for light (“T” for trace that is less than 10% of a plant utilized).

First study of seladang feeding habits was accomplished through field observation in Endau Rompin State Park (Ebil, 1991). He found that seladang utilized most the plants they like best. Many wildlife researchers are inclined to consider those plants utilized most as the ones most preferred. Such observations may be misleading because of the effect of

geographical influence on plant abundance and palatability, and on the stage of succession of the habitat regarding availability of certain plants. For example, some of the less preferred plants may receive heavy utilization on overstocked range (Provenza & Balph, 1987).

Subjective measurement data of seladang utilization and food preference can be gathered rather quickly, so large areas often can be sampled in a relatively short time. One subjective habitat evaluation technique based on available forage, described by Peek (1986) provided a useful index to forage abundance and required about 20 percent of the time required for analogous vegetative sampling techniques.

Twig count and twig length are two direct methods of measuring food utilization and preference of wildlife species in the field. In the twig-count method, browsed and un-browsed twigs on each sampled plant are counted and their ratio expressed as a percentage (Jensen & Scooter 1997). The investigators used variable-sized plots (1-2 mili-acres to 0.0025 acre), some of which were shaped as transects, often permanently installed and systematically established to represent the important habitats. The twig-length method determines the average normal length of twigs and the average length after browsing. Deer use is expressed as a percentage of normal twig length. These lengths may be measured or estimated. Ebil (1991) used the twig-count method to estimate the amount of current twig growth grazed on shrubs or browsed on grasses.

Previously more works have been done in the primary forest and least information from the other components of seladang habitat. In fact seladang consists of primary forest, secondary forest and agriculture areas. This entire habitat requires varieties of vegetation, minimum supply of water, adequate amount of shelter and space, which are needed for the species to survive in a specific location of their home ranges. To meet seladang habitat requirement in the area is one of the biggest challenges for the biologists and managers. A more comprehensive approach must be part of the management program rather than solely let the animals wondering inside the disturbed forests.

To fulfill their need and assure the conservation of seladang species, some inputs through research should be incorporated into the management programs. Many essential factors are needed for managing the seladang species especially the present habitat that is food preferences.

Seladang is a wide spectrum feeder that feed on grasses, herbs, shrubs, vines and trees saplings in undisturbed condition. Among grasses species taken that observed by Khan (1973) and Ebil (1982) are Rumput Chengkenit (*Paspalum conjugatum*), Centro legume (*Centrocima pubcsens*) and bamboo grass (*Danim triganum*). Feeding continues in secondary forest, browse on shrubs, plants, trees, woody vines, and creepers. Some of the most browsed items Mengkirai (*Trema angustifolia*), Mengkirai Bulu (*Trema tomentosa*), Mahang (*Macaranga spp*.), Simpoh spp. (*Dillenia ovata* and *D. indica*) and Petai kerayong (*Parkia javanica*) are favourite fruit of the seladang. Temperature influenced the feeding duration and the seladang may move into the primary forest for shelter. The second feeding cycle of the day lasted about 3 hours (from 5pm to 8 pm) in the secondary and oil palm plantation. Under natural condition each herd spent almost two weeks for browsing and grazing in one particular area before all of them start to move to the other part of their home range (Conry, 1980 and Conry, 1981).

The study on food preferences of seladang includes identification of food varieties and their availability between the habitat types in the Ulu Lepar area.

2. Methods

This study was conducted in Ulu Lepar, Kuantan, Pahang from 1st. November to 27th. December 2006. The nearest town is Pekan Sri Jaya that is about 14km from the study site. This area consists of three landscape types that include lowland dipterocarp forest, secondary forest, and oil palm estate (Figure 1).

The establishment of the first and subsequent plots was based on the seladang signs such as dung, beds, rest sites or feeding signs. Two plots were designed for primary forest, secondary forest and oil palm plantation respectively. A total of 72 sub-plots were established in the study area. Each plot consists of 12 sub-plots of 20mx20m dimension and each vegetation species eaten the plots were identified and recorded (Figure 2). The sub-plot was made randomly as suggested by Ebil (1981). Twig-count method was used to estimate the amount of current twig growth grazed or browsed on saplings, shrubs and grasses.

3. Results

3.1 Shrubs

A total of 17 species of shrubs were recorded in the study area. Most of the species were commonly found in the primary, secondary and agricultural areas. The twig count of shrubs species counted from twenty-four sub-plots in the primary forest, secondary forest and agriculture areas were 4968 twigs, 6086 twigs and 3098 twigs respectively (Table 1). From the table, the four most preferred species of shrub that the seladang browsed in the primary forest were *S. acuminata* (7.95%), *S. parvifolia* (7.37%), *Goniothalamus spp* (7.37%) and *Melastoma malabathricum* (7.21%). The five least preferred shrubs species eaten at the primary forest were *D. aromatica* (4.27%), *Dillenia ovata* (4.51%),

Macaranga tanarius (4.53%), *Scaphium spp.* (5.09%) and *Trema angustifolia* (5.15%).

In the secondary forest *Melastoma malabathricum* was the most preferable species of shrubs eaten by seladang with 10.42%. These were followed by *Intsia Palembanica* (8.12%), *Macaranga tanarius* (7.49%), *S. acuminata* (7.10%) and *S. parvifolia* (6.84%). Majority of sub-plots in the secondary forest had *Melastoma malabathricum* and became favorable food species to the seladang. *Atalantia monophylla* (3.30%) and *lithorcapus spp* (3.5%) were recorded as the least preferred species eaten by seladang in the secondary forest.

Results in Table 1 also indicated that food variety for seladang was limited to only ten species in the agriculture area. Shrub species such as *S.parvifolia, S. acuminata, Intsia Palembanica, Atalantia monophylla, Scaphium spp.* and *D. aromatica* were absent in the agriculture area. The most five preferred species of shrubs eaten by seladang were *Erythrina variegata* (18.56%), *Macaranga gigantea* (11.9%), *Parkia javanica* (10.75%), *Macaranga tanarius* (10.68%) and *Trema orientalis* (10.01%).

Results in Table 2 shows that both the amount of twigs eaten compared to the available grass species and locations (sub-plots) in the primary forest were significantly different at $p< 0.010$ and $p< 0.006$ respectively. In the secondary forest, twigs-species were highly significantly different ($P<0.000$). ANOVA also indicated that the twigs eaten by seladang between sub-plots were not significant different ($p<0.826$). Similar pattern indicated with the twigs and species eaten by seladang in the agriculture area was highly significant different ($P<0.000$) among the species.

3.2 Grasses

Grass species eaten by seladang from each sub-plot of the primary forest, secondary forest and agriculture areas were summarized in the Table 3. There were only six species of grasses found in this study area. A total of 3056 twigs of grasses were eaten by seladang in an agriculture area. Out this total 19.76% was *Paspalum vaginatum* and it was the most preferable grass species eaten by seladang compared to *Panicum maximum* (12.51%) in this area. In the secondary forest*, Paspalum conjugatum* (20.80%) was the most preferable. However, out of 1663 twigs count for all grass species in the primary forest 19.06% of *Imperata cylindrica* was eaten by seladang.

Table 4 was a summarized ANOVA for grass species in the three habitat types at Ulu Lepar, Pahang. As the amount of twigs was compared to the grass species in the primary forest, secondary forest and agriculture area, none of them was significantly different. However, comparison between the amount of twigs eaten and sub-plots was significantly different both in primary and secondary forests at $P<0.002$ and $P<0.049$ respectively.

4. Discussions

Seladang is among small ruminant's mammal species that require large quantities of easily digested food in order to satisfy their metabolic requirements for maintenance, growth and reproduction. These animals spent most of the time in their habitat are searching for food of the best quality. This is shown by diverse type of food species in the diets. The different habitat types within the home range influenced the availability of the preferred species eaten by seladang. Thus, the seladang has to move quite a distance in the home range. The phrenology of herbaceous and woody plant species changes with the types of habitat. This variation in the locality of plants is accompanied by changes in nutrient composition and in digestibility by seladang (William, 2006).

Results in the Tables 1 were showing the browsing preferences of shrub species in the primary forest, secondary forest and agriculture area. The preferences on shrubs were estimated based on the number of twigs of shrub species eaten by seladang. The number of twigs for shrub species in the secondary forest was highly browsed by seladang compared to the primary forest (6086 twigs). The amounts of shrub species found in the secondary forest are young, shorter in height and abundance. However, in the primary forest many shrub species are trees and less number of young saplings. In the agriculture area, the browsing activities were low as the area was planted with mono crops species (oil palm trees). From direct observation made in the study area, shrub species were abundant mostly at the fringes of the forest boundary. There were less species of shrubs in the agriculture area.

The differences in feeding preferences could be due to the availability of the shrub species dominant in that location within the home range. Quality of food and energy requirements for different age and sex classes at different times of the year of seladang also influences feeding preferences (Saharudin, 1984). In secondary forest for example, the effect of after logging may encourage *Melastoma malabathricum* (Senduduk) species to emerge and geminates at faster rate over the open spaces and established as dominant species with vast areas.

The amount and species of grasses eaten by seladang varied from one location (habitat types) to another. Results in Table 3 indicated that preferred grass species to be grazed by seladang dependence of habitat types. In the primary forest, *Imperata cylindrica* was highly dominated in most of the sub-plots that readily to be grazed by seladang before rests as local temperature discourage them to proceed to the open spaces in the agriculture area. *Paspalum conjugatum* was highly preferred among the grass species by seladang in the secondary forest. But, the characteristics of *Paspalum vaginatum* that occupies an exclusive niche of saline and wet conditions attract seladang to graze more of these species

while searching for the water supply. Thus, *Paspalum vaginatum* become more preferable than any other available grasses found in agricultural area.

Results in Tables 3 also showed that the feeding trend of seladang on grasses species differed as they moved from primary forest to agriculture areas. In the agricultural area grazing of grasses are more prominent over primary and secondary forest. This was due to higher amount of grasses regardless of the species in agricultural area compared to primary and secondary forests.

Seladang populations can grow to exceed their food supply. An overuse of foods within its habitat may reduce the productivity of the food population and resulting in lower productivity after overuse. Consequently, food shortages result in starvation and low birth rates, unless some other factor reduces numbers of other competitors (Charles & Tony 2001).

5. Conclusion

From this study, it is found that seladang likes to eat varieties of food species. The percentage of shrubs species eaten by seladang in the study area was significantly different as most of the shrubs found in each habitat greatly governed by the forest type. The species of grasses such as *Imperata cylindrica, Paspalum conjugatum* and *Paspalum vaginatum* that found in the study area could be excellent indicators for the present of seladang in each habitat type. It is strongly recommended that future study on the indicator of food preference for seladang. Further study on the food contents *Imperata cylindrica, Paspalum conjugatum* and *Paspalum vaginatum* as future findings could help the management of seladang using Ex-situ approaches to consider the types of food species to be introduced in the paddocks.

Efficiency of data collection could increase the accuracy of the results. This could be done with more plots which cover the study area. Study duration also influenced the accuracy of the results. The future study should consider to be carried out for longer period to examine diversity of food and it's different.

References

Charles T. R and, Tony J. C. (2001). Wildlife Feeding and Nutrition, Second Edition. Academic Press, New York, pp 161.

Conry, P. (1981). Habitat selection and use, movements and home range of the Malayan seladang (Bos gaurus hubbacki) in Central Pahang, Malaysia.Unpublished M.Sc. thesis, University of Montana.

Ebil, Y. (1981). A Review of the Malayan Seladang (Bos gaurus hubbacki). Department of Wildlife and National Parks.

Ebil, Y. (1982). Habitat requirement for the Malayan Gaur. J. Wildl and Parks 1: 7-16.

Ebil, Y. (1991). The study of forage utilization of seladang in Ulu Lepar, Pahang. J. Wildl. and Parks. 11:1-11.

Jensen, C.H., and G. W. Scooter. (1997). A comparison of twig-length and browsed-twig methods of determining browse utilization. J. Range Manage. 30:64-67.

Momin, Khan, M. K. (1973). Studies on the seladang (Bos gaurus) in the State of Perak. Malaysian Nature Journal 26:163-169.

Peek, J.M. (1986). A review of wildlife management. Prentice-Hall, Englewood Cliffs, NJ. 486.

Provenza, F.D., and D.F. Balph. (1987). Diet learning by domestic ruminants: theory, evidence and practical implications. Appl. Anim. Behav. Sci. 18:211-232.

Saharudin, A. (1984). Habitat sustainability Index Model: Seladang (Bos gaurus hubbacki). J. Wildl. and Parks. 3: 68-74.

Robert, A. G and Gary C. W. (1997). Analysis of Wildlife Radio-Tracking Data,. Publisher: Elsevier , 121 pp.

William, J. S. (2006). Ecological Census Techniques: A Handbook. Cambridge University Press, New York, 136 pp.

Table 1. Percentage of twig of shrubs species eaten by seladang in different habitat types at Ulu Lepar, Pahang

	Primary			Secondary			Agriculture		
Species	N	Mean	%	N	Mean	%	N	Mean	%
Dillenia ovata (Simpoh gajah)	224	17.92	4.51	225	9.38	3.70	NA	NA	NA
Melastoma malabathricum (Senduduk)	358	28.64	7.21	634	26.42	10.42	225	9.38	7.26
Shorea parvifolia (Meranti sarang punai)	366	29.28	7.37	416	17.33	6.84	NA	NA	NA
Shorea acuminata (Meranti rambai daun)	395	31.60	7.95	432	18.00	7.10	NA	NA	NA
Intsia Palembanica (Merbau)	270	21.60	5.43	494	20.58	8.12	NA	NA	NA
Erythrina variegata (Dedap)	266	21.28	5.35	415	17.29	6.82	575	23.96	18.56
Macaranga tanarius (Mahang semut)	225	18.00	4.53	456	19.00	7.49	331	13.79	10.68
Macaranga gigantea (Mahang kapur)	267	21.36	5.37	263	10.96	4.32	359	14.96	11.59
Trema angustifolia (Mengkirai)	256	20.48	5.15	390	16.25	6.41	264	11.00	8.52
Trema tomentosa (Mengkirai bulu)	282	22.56	5.68	342	14.25	5.62	310	12.92	10.01
Parkia javanica (petai)	334	26.72	6.72	343	14.29	5.64	333	13.88	10.75
Goniothalamus spp (Mempisang)	366	29.28	7.37	201	8.38	3.30	NA	NA	NA
Scaphium spp (Kembang semangkok)	253	20.24	5.09	315	13.13	5.18	NA	NA	NA
Atalantia monophylla (Merlimau)	282	22.56	5.68	293	12.21	4.81	225	9.38	7.26
Lithocarpus spp (Mempening)	320	25.60	6.44	213	8.88	3.50	210	8.75	6.78
Dryobalanops aromatica (Kapur)	212	16.96	4.27	294	12.25	4.83	NA	NA	NA
Endospermum malaccense (Sesendok)	292	23.36	5.88	360	15.00	5.92	266	11.08	8.59
Total	4968			6086			3098		

Table 2. Analysis of variance (ANOVA) for shrubs species in the three habitat types at Ulu Lepar

Habitat types	Compare	Sum of Squares	df	Mean Square	F	Sig.
Primary forest	Twigs - Species	2032.46	16	127.03	2.046	0.010
	Twigs - Plot	2759.73	23	119.99	1.956	0.006
Secondary forest	Twigs - Species	8351.33	16	521.96	5.44	0.000
	Twigs - Plot	1896.58	23	82.46	.720	0.826
Oil Palm Plantation	Twigs - Species	4254.07	9	472.67	5.29	0.000
	Twigs - Plot	2346.39	23	102.02	.98	0.490

$\alpha < 0.05$

Table 3. Percentage of grass species eaten by seladang in different habitat types at Ulu Lepar, Pahang

	Primary			Secondary			Agriculture		
Species	N	Mean	%	N	Mean	%	N	Mean	%
Centrocima pubcsens (Selaput tunggul)	268	11.17	16.12	347	14	15.01	497	20.71	16.26
Paspalum conjugatum (Rumput chengkenit)	283	11.79	17.02	481	20	20.80*	452	18.83	14.79
Paspalum vaginatum (Rumput dawai)	308	12.83	18.52	391	16	16.91	604	25.17	19.76*
Danim triganum (Rumput buluh)	279	11.63	16.78	392	16	16.96	478	19.92	15.64
Panicum maximum (Rumput kuda/sambar)	208	8.667	12.51	353	15	15.27	453	18.88	14.82
Imperata cylindrica (Lalang)	317	13.21	19.06*	348	15	15.05	572	23.83	18.72
Total	1663			2312			3056		

Table 4. Analysis of variance (ANOVA) for grass species in the three habitat types at Ulu Lepar, Pahang

Habitat types	Compare	Sum of Squares	df	Mean Square	F	Sig.
Primary Forest	Twigs - Species	310.12	5	62.02	1.09	.368
	Twigs - Plot	2481.16	23	107.88	2.28	.002
Secondary forest	Twigs - Species	318.25	5	63.65	0.83	.533
	Twigs - Plot	2599.08	23	113.00	1.63	.049
Oil Palm Plantation	Twigs - Species	853.47	5	170.70	1.30	.268
	Twigs - Plot	3375.22	23	146.75	1.13	.327

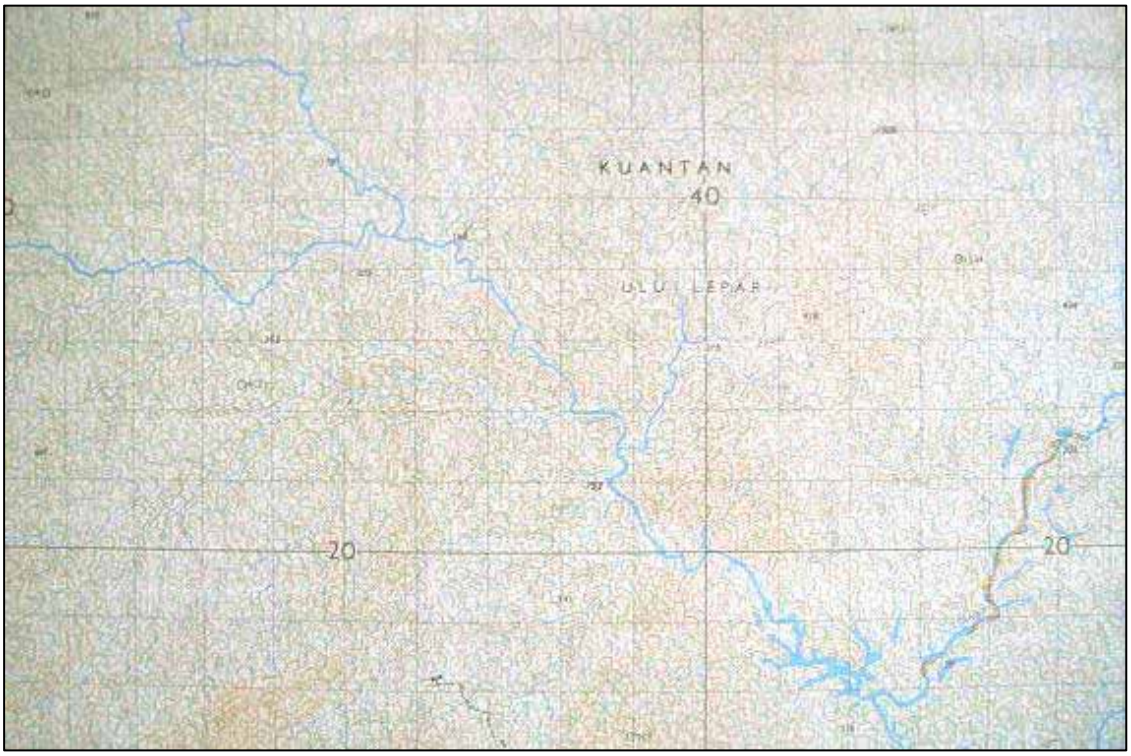

Figure 1. The study area at Ulu Lepar Pahang consisting of primary forest, secondary forest and agriculture area with an estimated size of 13,000 ha and drained by two major rivers such Sungai Lepar and Sungai Berakit.

Estimated number of seladang is 96 animals (Ebil 1981).

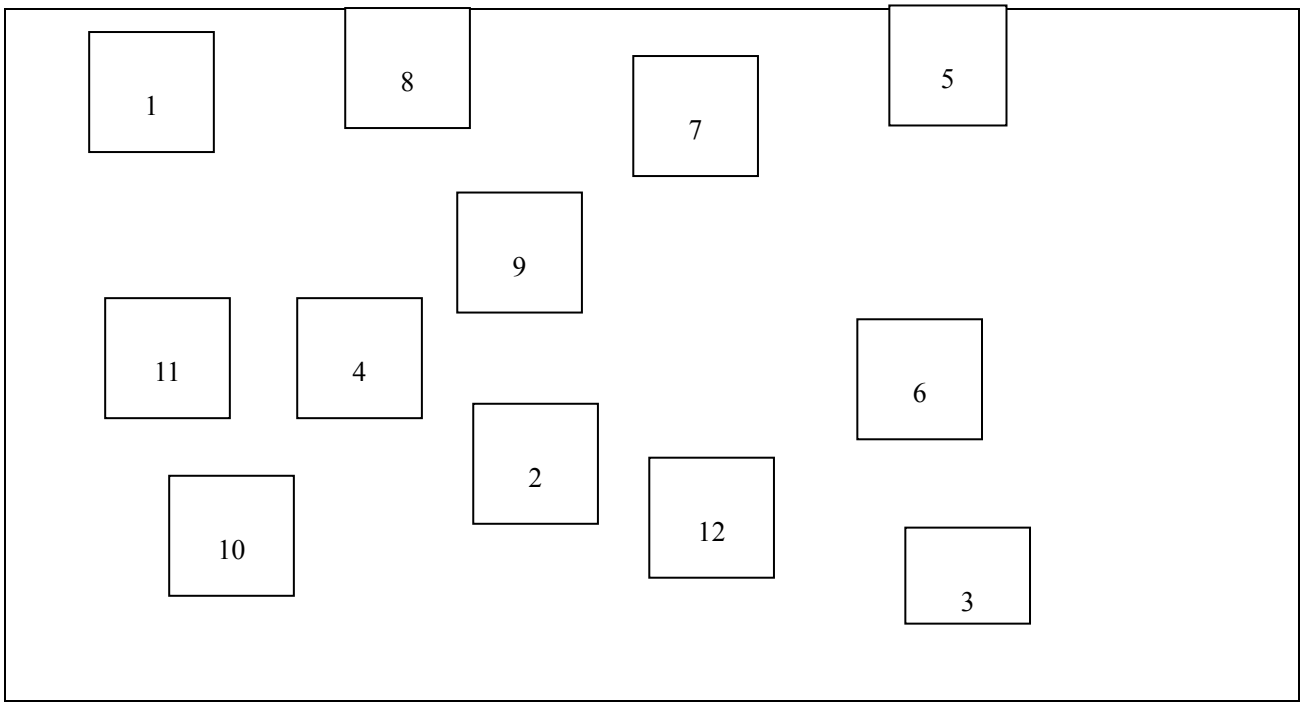

Figure 2. Design of sub-plots, where individually has a measurement of 20x20m. It was established either based on dung's sign, beds, resting sites or feeding signs. If either one of these signs found, sub-plot will be established

(Adopted from Ebil (1981))

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Community Leaders' Perceptions toward Tourism Impacts and Level of Community Capacity Building in Tourism Development

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Abstract

This paper attempts to identify the relationship between the community leaders' perceptions toward tourism impacts and their effort in building the capacity for tourism development in local communities of Shiraz, Iran. The paper is based on the study carried out among 175 communities' leader. The analysis of data uses Pearson correlation to determine the relationship between variables involved. The findings reveal that two impacts (economic and environmental) have the most significant relationship with the level of community capacity building. The findings of the study imply that those leaders who perceived the tourism activities could bring economic benefits would have the higher tendency to be actively involved in building the capacity of their communities in relation to the development of tourism, whereas those who perceived tourism could bring negative impact to the environment, would put less effort in the capacity building.

Keywords: Community perception, Tourism impacts, Community capacity building, Local communities

1. Introduction

In many countries, tourism is a fast growing industry and a valuable sector. Tourism contributes significantly to the countries' economy. Moreover, tourism plays an increasingly important role in the development of communities. The benefits of tourism include both tangible (e.g. job creation, state and local tax revenue, etc.) and less tangible (e.g. social structure, quality-of-life, etc.). In addition, tourism can, and often does, result in less desirable effects on the economic, social, and environmental fabrics of communities. These benefits and costs provide ample opportunity for creative public policy debate. In other words, tourism affects the economy and lives of communities. There are real and perceived fears that are sometimes attributed to tourism. These impacts of tourism on communities could influence the communities' effort to develop the industry. In relation to this, the main focus of this paper is to identify the relationship between communities' perception towards the impacts of tourism and their effort to build their community capacity in relation to tourism development.

Community perception towards the tourism impacts on a community can vary significantly. According to Sharma (2004), positive attitudes towards tourism impacts among communities residents will result in more successful tourism development. Thus, understanding the community perception can help to access community support for continued tourism development through community capacity building. Gursoy & Rutherford (2004) suggested that tourism developers need to consider the perception and attitude of residents before they could start investing scarce resources. Moreover, understanding of community perception towards tourism impacts can also help to identify types of tourism which have the potential for building community capacity (Moscardo, 2008, p. 86). Meanwhile, several studies indicate that people who have an economic gain from tourism perceive more positive impact from it (Chon, 2000). In this present study, it is assumed that community perception towards tourism impacts does have a considerable effect on the level of community capacity building in tourism development. In the study, the researchers employ exchange theory in order to explain the relationship between perception towards tourism impacts and the level of community capacity building. Tourism has been proved as one of the most ingeniously crafted and expedient opportunities for social exchange (Singh, Timothy, & Dowling, 2003). Thus, in this study, social exchange theory is considered as a conceptual sociological approach to the study of leaders' perceptions towards tourism impacts and its relationship with their effort

for community capacity building in tourism development. However, the researcher did not find any study about the relationship between the perceptions towards tourism impacts and level of community capacity building.

2. Literature review

The tourism industry has human and environmental costs, besides its benefits to communities involved. Thus, some communities have to make a choice whether to adopt tourism or reject it as a source of income. For the communities which adopted tourism as one of the development alternatives, they would put more effort in developing the tourism industry. Some local communities would attempt to build their community capacity in relation to tourism development. Community capacity building can be seen as the capacity of community residents to participate in community development activities, both as individuals and through groups and organizations. In relations to tourism development, community capacity building is a necessary condition for improving the process of tourism development and enhancing its benefits for local communities. Hence, the main objective of this study is to investigate relationship between community leaders' perceptions of tourism impacts and their effort for building capacity in tourism development.

A number of theories have been suggested to explain the nature of residents' perception towards tourism impacts and their support to tourism development. Among the theories are conflict theory, community attachment theory, dependency theory, and social exchange theory. However, most of studies utilize the social exchange theory, which has been considered as the most appropriate framework to develop and understand community residents' perception (Ap, 1992). Social exchange theory is used predominately in the literature on assessing tourism impacts for a particular destination (Andereck & Vogt, 2000; Andriotis, 2005; Ap, 1992; Chen, 2000, 2001; Gursoy et al., 2002; Vogt & Jun, 2004). Social exchange theory can strengthen the belief that a need exists to measure the level of active participation of community residents in the community development planning process associated with tourism development (Wang & Pfister, 2008). In the tourism literature, a number of studies have utilized the social exchange theory to explain community perception and reactions to tourism development (Ap, 1992; Jurowski et al., 1997; Yoon et al., 2001). Most of these studies evaluate community residents' perception and assessments of cost and benefits of tourism and their effort for further tourism development in their particular regions. The social exchange theory explains how people react and support tourism development (Ap, 1992; Yoon et al., 2001). In other words, social exchange theory supports that community residents calculate the costs and benefits of tourism development, and their effort for tourism development depends on the outcome of this cost-benefits calculation (Andriotis, 2005). Moreover, according to Andriotis & Vaughan (2003), social exchange theory allows the investigation of positive and negatives perception towards tourism impacts in a community. It is more than likely, that residents will be aware of the positive and negative implications of tourism and whether to support or not to support the tourism development is based on their perception of the benefits and costs (Andriotis & Vaughan, 2003). Thus, in the present study, social exchange theory could explain the relationship between community perception towards tourism impacts and their action to get involved in the community capacity building in tourism development. The Figure 1 illustrates this issue.

Tourism industry not only provides means of recreation to the tourists but offers assistance to the ailing and developing economies of the world. Many countries depend on tourism for income. The entrepreneurs, communities and states find immense commercial opportunities in tourism and have made intense efforts to reap the benefits. The net result is the generation of wealth. But this wealth generation is not without a price. For the development of tourism, environment, societies and cultures at the destination has paid a heavy price. The present cause of concern is not only the development but to tackle the challenges posed by development (Chaudhary et al., 2007). In the case of the impacts of tourism, Ming and Wong (2006) have studied the homestay operators perception towards the tourism impact on their community and how their social demographics influence their perception towards tourism. Using factor analysis the impacts on the local community perceived by the homestay operators were condensed into seven factors: economic impacts, the interaction between tourism and other sectors, life quality improvement, general physical environment deterioration, beach degradation, sea water pollution, and interruption to quiet life. However, the economic and social impacts of tourism are a big subject that cannot be covered thoroughly here. Economically, tourism can create jobs for local people and bring money into the country. Since tourists spend money on travel, hotels, food, entertainment and recreation, they can be an important source of income and thus of economic development for the communities with few other possible sources of revenue. Meanwhile, a study by Nyaupane and Thapa (2006) indicates that generally, on comparison of descriptive and statistical analyses, local residents were consistently more likely than managers to perceive fewer negative and greater positive impacts of tourism on the environment. Quite a number of studies are related to the studying the impacts of tourism, however, seldom could we find studies that deal the relationship between community leaders' perception towards tourism impacts and community capacity building in relations to tourism development.

3. Research Methodology

The study was carried out in 175 local communities in Shiraz. Shiraz is the capital of the Iranian province of Fars, the ancient homeland of the Achemenian (ca.549-330 B.C.E) and the Sassanian (ca.224-651 C.E) dynasties. The Greeks

called this area Persia, from which came their beloved national language, Farsi, from the name of this province (Limbert, 2004, p. 3). Shiraz is a central area for Persian civilization and culture. Shiraz has a population of more than 1,000,000 people. It is situated in the south western region of Iran, in the inlands of about 200km from the Persian Gulf at an elevation of 1,800 meters above sea level. Shiraz also is one of the most popular cultural tourism destinations in Iran with a long interesting history of the Roman Empire (Cultural Heritage News Agency, 2006). Throughout history, foreign visitors to Shiraz have praised the city's gardens, its site, its clear air, its wines, and the charm of its people. Iranians themselves, however, have long treasured Shiraz as a city of Islam. Its traditional Iranian name is Dar al -Elm (Abode of Knowledge) (Limbert, 2004).

The data for this study were collected from community leaders. Community leadership was identified as a key factor in developing tourism in local communities (Aref & Ma'rof, 2009; Moscardo, 2008). According to Eyler et al. (1999), Thompson et al. (2000), and Von et al. (1992) community leaders are able to speak for the community because of their knowledge and their roles in the community. For this study, community leader is defined as those who can influence policy, or opinion, or action on community because of their roles and positions in the community (Aref et al., 2009). For the purpose of this survey, questionnaire was designed for data collection. Moutinho (2000) believed that questionnaire is the most commonly used in tourism marketing research. The items in the questionnaire for this survey were measured using Likert scale. The Likert scale commonly used in marketing research (Grover & Vriens, 2006). Pearson Coefficient Correlation was used to measure relationship between the variables. Pearson correlation statistic is a statistical technique to measure the strength of the association that exist between two quantitative variables (Ary et al.,1996). The purpose of the study is to measure the strength of relationship between two main variables (the perception towards the tourism impacts and the level of community capacity building). In statistics, correlation (often measured as a correlation coefficient) indicates the strength and direction of a linear relationship between two random variables. In this study community capacity building is a composite variable, consisting of eight domains, namely, participation (7 items), community leadership (6 items), community structure (5 items), skill and knowledge (5 items), community power (5 items), sense of community (7 items), resource mobilization (5 items) and external support (5 items). Meanwhile, there are three variables of tourism impacts, namely social-cultural impact (10 items), environmental impacts (5 items), and economic impacts (5 items). The study used Likert-scale to measure every item. In the analysis, the community capacity building variable was correlated with the three variables of perception of tourism impacts in order to determine the strength of their relationships. Meanwhile, descriptive statistics were applied to describe the variables understudied.

4. The findings of the study

As have been mentioned above, the main objective of the study is to determine the relationship between community leaders' perception towards tourism impacts and their effort for community capacity building in tourism development. Pearson correlation was used to identify these relationships. Table 1 shows the findings of the study in relations to means and standard deviations of the studied variables. For the three variables related to impacts of tourism (environmental, economic and socio-cultural), the data reveal that generally, the leaders have high perception scores for every variable. This is reflected by the means of every variable - socio-cultural impacts (M = 37.77, SD = 3.114), environmental impacts (M = 17.45, SD = 2.935), economic impacts (M = 17.24, SD = 2.346), and total impacts (M=72.46, SD= 6.002). These findings imply that most of the leaders have agreed with the impacts of tourism on the economy, environment and socio-cultural of their communities. Moreover, the standard deviations reflect that there are relatively small deviations (differences) between respondents (leaders) in terms of their perceptions towards the impacts of tourism. Meanwhile, the mean of leaders' effort of community capacity building in relation to tourism development is relatively low (M=129.47, SD= 19.445). It implies that majority of the leaders have less effort in the development of tourism activities. In Iran, tourism industry is not one of main focuses of development of the country. Thus, it is understood that majority of the communities in Iran have given less focus on the development of the industry.

The second analysis for this paper focuses on the relationships between the perception towards tourism impacts and the effort of community capacity building in relation to tourism development. The results of the analysis are shown in Table 2. The correlation between socio-cultural impacts and level of community capacity building is found to be non significant ($r = -.092$, $N = 175$, $p = .224$, two-tailed). Meanwhile, the correlation between economic impacts and the level of community capacity building is found to be positively significant ($r = .252$, $N = 175$, $p < .001$, two-tailed), whereas the correlation between perception towards environmental impacts is negatively significant($r = -.257$, $N = 175$, $p < .001$, two-tailed). Lastly, the correlation between the overall (total) perception of the tourism impacts and the level of capacity building is statistically non significant ($r = -.075$, $N = 175$, $p = .325$, two-tailed).

When comparing the socio cultural, environmental and economic impacts of tourism and total tourism impacts descriptively, economic impacts show positive relationship with the level of community capacity building in tourism development. However, environmental impacts have negative significant relationship with community capacity building in tourism development. These findings support the assumption that the communities will support the tourism

development if the development bring about benefits, such as economic benefits that outweigh the costs of sharing environmental and social resources with tourists (Harrill, 2004). In addition, Martin et al (1998) found that retirees were less supportive of tourism development and identified more with the negative impacts of tourism. They conclude that those who did not receive real economic gain from the tourism growth would not support further development. The findings from this study supported the previous studies in terms of positive tourism impacts and their support for tourism development. The findings of studies related to economic impacts are consistent with the past studies that have been conducted by Ap (1992) and Yoon et al (2001). These studies evaluated community residents' perception and assessments of cost and economic benefits of tourism and their support for further tourism development in their communities.

Social exchange theory supports that community residents balance the costs and benefits of tourism development, and their support for tourism depends on the outcome of this cost-benefits equation (Andriotis, 2005). Thus, according to Mason (2003), the economic impacts of tourism are the most widely researched impacts of tourism on a destination. Studies by Andereck & Vogt (2000) also support the findings of the present study. According to their studies, there is a relationship between community residents' support for tourism development and their perception toward tourism impacts. However, it can infer that community leaders' support for community capacity building in tourism development is positively related to their benefits from tourism development. Empirical findings from these studies have suggested that people will act to maximize benefits and minimize costs in different situations. They also weigh total benefits against total costs that effect their decision to participate in tourism decision making and tourism development planning (Kayat, 2002; Lawler, 2001; Yoon et al., 2001). Andriotis & Vaughan (2003) also found that when the exchange of the economic, social, and environmental resources is at least perceived as balanced by the local communities, only the then tourism is perceived positively by residents. However, they caution that the benefits of tourism may be experienced by only a handful of individuals in the community, and only those who benefit will be more likely to support tourism development. In order to have tourism supported by all community members of the community, the benefits of tourism must be evenly distributed (Andriotis & Vaughan, 2003).

5. Conclusion

By using social exchange theory framework, this paper attempts to illustrate the relationship between perception towards tourism impacts and the level of community capacity building. This theory helps to create a clear understanding about the relationship between perceived impacts and support for tourism development (Perdue et al., 1990). From the study, it is found that the correlation between perception of economic impacts and level of community capacity building is positively significant, whereas the correlation between environmental impacts of tourism and the level of community capacity building is negatively significant. Thus, it could be concluded that the higher the perception of the communities leaders towards the economic impacts, the higher their tendency that to put their effort in building their community capacity in relation to tourism development. On the other hand, if the leaders perceived that tourism could bring environmental damage to their communities, there is a tendency that they will not put their effort in the tourism development. These findings have an implication on the understanding and managing tourism impacts. It is suggested that the well managed tourism can make a positive contribution to destinations, and thus it could received a support from the local communities. As one of the world's largest industries, tourism carries with it significant social, environmental, economic and political impacts. Although tourism can provide significant economic benefits for some destinations, however, the image of tourism as a benign and environmentally friendly industry has often been challenged. There is a clear and growing body of evidence suggests that the effects of tourism development are far more complex than policy-makers usually suggest and that the impacts of tourism occur not just at the destination, but at all stages of a tourist's trip. Furthermore, tourism does not exist in a vacuum. Broader social and environmental changes also shape the form, growth and experience of tourism development. Meanwhile, according to Moscardo (2008), a lack of entrepreneurial capacity, limited understanding of tourism markets and a lack of community understanding of tourism and its impacts have been identified as barriers to effective tourism development in peripheral regions. Thus, the findings of this study could assist community leaders in the design and implementation of tourism development strategies in communities that are undertaking tourism planning.

References

Andereck, K., & Vogt, C. (2000). The relationship between residents' attitudes toward tourism and tourism development options. *Journal of Travel Research, 39*(1), 27-36.

Andriotis, K. (2005). Community Groups' Perceptions of and Preferences for Tourism Development: Evidence from Crete. *Journal of Hospitality & Tourism Research, 29*(1), 67-90.

Andriotis, K., & Vaughan, R. D. (2003). Urban residents' attitudes toward tourism development: The case of Crete. *Journal of Travel Research, 42*, 172-185.

Ap, J. (1992). Residents' perceptions on tourism impacts. *Annals of Tourism Research, 19*(4), 665-690.

Aref, F., & Ma'rof, R. (2009). Community Leaders' Characteristics and their Effort in Building Community Capacity for Tourism Development in Local Communities. *International Journal of Business and Management, 4*(10).

Aref, F., Ma'rof, R., & Sarjit, S. G. (2009). Community Perceptions toward Economic and Environmental Impacts of Tourism on Local Communities. *Asian Social Science, 5*(7), 130-137.

Ary, D., Jacobs, C., & Rezavieh, A. (1996). *Introduction to research in education* (5 ed.). New York: Harcourt Brace College Publishers.

Chaudhary, M., Kamra, K. K., Boora, S. S., Kumar, R. B., Chand, M., & Taxak, R. H. (Eds.). (2007). *Tourism Development : Impacts and Strategies*. New Delhi: Vedams eBooks (P) Ltd.

Chen, J. S. (2000). An investigation of urban residents' loyalty to tourism. *Journal of Hospitality and Tourism Research, 24*, 5-19.

Chen, J. S. (2001). Assessing and visualizing tourism impacts from urban residents' perspectives. *Journal of Hospitality and Tourism Research, 25*, 235-250.

Chon, K. S. (2000). *Tourism in Southeast Asia: a new direction*. New York: Haworth Hospitality Press.

Cultural Heritage News Agency. (2006). Shiraz to be registered in UNESCO's city of literature. Retrieved 1.April, 2008, from http://www.chnpress.com/news/?section=2&id=6162CHN(Cultural

Eyler, A., Mayer, J., Rafi, R., Housemann, R., Brownson, C., & King, C. (1999). Key informant surveys as a tool to implement and evaluate physical activity interventions in the community. *Health Education Research, 14*(2), 289.

Grover, R., & Vriens, M. (2006). *The handbook of marketing research: uses, misuses, and future advances*: Sage Publications.

Gursoy, D., Jurowski, C., & Uysal, M. (2002). Resident attitudes: A Structural Modelling Approach. *Annals of Tourism Research, 29*(1), 79-105.

Gursoy, D., & Rutherford, D. G. (2004). Host attitudes toward tourism: An Improved Structural Model. *Annals of Tourism Research, 31*(3), 495-516.

Harrill, R. (2004). Residents' attitudes toward tourism development: A literature review with implications for tourism planning. *Journal of Planning Literature, 18*(3), 251-266.

Jurowski, C., Uysal, M., & Williams, R. (1997). A theoretical analysis of host community resident reactions to tourism. *Journal of Travel Research, , 36*(2), 3.

Kayat, K. (2002). Power, social exchanges and tourism in Langkawi: Rethinking resident perceptions. *The International Journal of Tourism Research, 4*(3), 171-191.

Lawler, E. J. (2001). An affect theory of social exchange. *The American Journal of Sociology, 107*(2), 321-325.

Limbert, J. W. (2004). *Shiraz in the age of Hafez: the glory of a medieval Persian city*. Seattle: University of Washington Press.

Martin, B., McGuire, F., & Allen, L. (1998). Retirees' attitudes toward tourism: Implications for sustainable development. *Tourism Analysis, 3*, 43-51.

Mason, P. (2003). *Tourism impacts, planning and management*. Jordan Hill, Oxford: Butterworth–Heinemann.

Ming, G. a., & Wong, P. P. (2006). Residents' Perception of Tourism Impacts: A Case Study of Homestay Operators in Dachangshan Dao, North-East China. *Tourism Geographies, 8*(3), 253 - 273.

Moscardo, G. (Ed.). (2008). *Building community capacity for tourism development*. Australia.

Moutinho, L. (Ed.). (2000). *Strategic management in tourism*. University of Glasgow Business School, UK: CABI Publishing

Nyaupane, G. P., & Thapa, B. (2006). Perceptions of environmental impacts of tourism: A case study at ACAP, Nepal. *The International Journal of Sustainable Development and World Ecology, 13*(1), 51-61.

Perdue, R. R., Long, P. T., & Allen, L. (1990). Resident support for tourism development. *Annals of Tourism Research, 17*(4), 586-599.

Sharma, K. k. (2004). *Tourism And Socio-cultural Development*. New Delhi: Sarup and Sons.

Singh, S., Timothy, D. J., & Dowling, R. K. (Eds.). (2003). *Tourism in destination communities*. Cambridge, USA: CABI publishing.

Thompson, B., Lichtenstein, E., Corbett, K., Nettekoven, L., & Feng, Z. (2000). Durability of tobacco control efforts in the 22 community Intervention trial for smoking cessation (COMMIT) communities 2 years after the end of intervention. *Health Education Research, 15*(3), 353-366.

Vogt, C. A., & Jun, S. H. (2004). *Residents' attitudes toward tourist market segments and tourism development in Valdez, Alaska: A comparison of residents' perceptions of tourist impact on the economy and quality of life.* Paper presented at the Proceedings from the 2004 Northwest Recreation Research Symposium.

Von Kroff, M., Wickizer, T., Maeser, J., O'Leary, P., Pearson, D., & Beery, W. (1992). Community activation and health promotion: identification of key organizations. *American Journal of Health Promotion, 7*, 110-117.

Wang, Y., & Pfister, R. E. (2008). Residents' Attitudes Toward Tourism and Perceived Personal Benefits in a Rural Community. *Journal of Travel Research, 47*, 84-93.

Yoon, Y., Gursoy, D., & Chen, J. (2001). Validating a tourism development theory with structural equation modelling. *Tourism Management, 22*(4), 363-372.

Table 1. Means and Standard Deviation of the studied Variables

Variables	Mean	Standard Deviation
Perception towards cultural impact	37.77	3.114
Perception towards economic impacts	17.24	2.346
Perception towards environmental impacts	17.45	2.935
Total perception	72.46	6.002
Community capacity building	81.02	23.763

Table 2. Pearson Correlation Matrix among Tourism Impacts and Level of CCB

	1	2	3	4	5
1-Socio-cultural impacts	1				
2. Environmental impacts	.354**	1			
3. Economic impacts	.166*	.240*	1		
4. Total impacts	.757**	.767**	.594**	1	
5. Community capacity building	-.092	-.257**	.252**	-.075	1

*P<.05 **p<.01

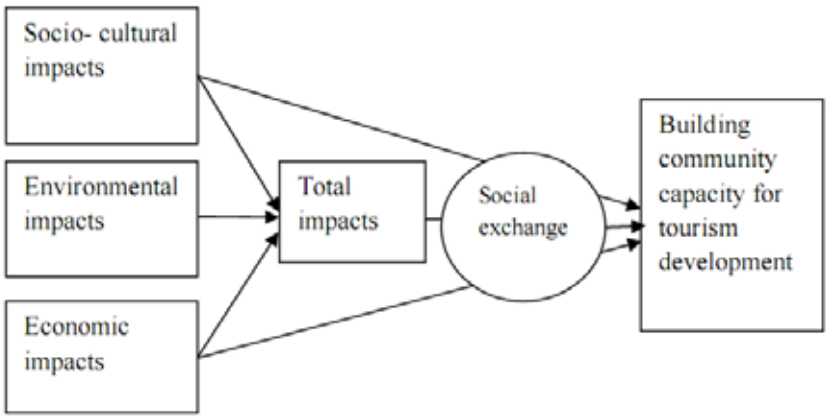

Figure 1. Tourism Impacts and Support for Community Capacity Building in Tourism Development

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Development of Environmentally Friendly Modified Fe-PAN Fibrous Catalyst and Its Application in Degradation of Dye

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Abstract

Modified Fe-PAN fibrous catalyst (Fe-AO-PAN) was formulated at the room temperature by the reaction of amidoxime (AO) modified polyacrylonitrile (PAN) fiber (AO-PAN) with $FeCl_3$, which was in turn used as an environmentally friendly heterogeneous photocatalyst in the oxidative degradation reaction of the standard target dye Rhodamine B in the presence of hydrogen peroxide. This paper investigated the influences of the iron ion concentration in solution (C_{Fe}) and reaction temperature to the iron ion content in Fe-AO-PAN catalyst ($C_{Fe\text{-}AO\text{–}PAN}$); studied the effects of $C_{Fe\text{-}AO\text{–}PAN}$, pH, intensity of light irradiation and etc. on the decoloration rate of the dye; and analyzed the oxidative degradation procedure of the dye by ultraviolet-visible light spectrum analysis. The results indicate that $C_{Fe\text{-}AO\text{–}PAN}$ increases with the rise of C_{Fe} or reaction temperature; the decoloration rate of Rhodamine B increases with the rise of $C_{Fe\text{-}AO\text{–}PAN}$ or radiation intensity, as well as the decrease of initial concentration of the dye; and Fe-AO-PAN shows higher catalytic activity in the solution of pH less than or equal to 6.0, however lower catalytic activity in a strongly basic medium. In addition, ultraviolet-visible light spectrum analysis proves that Fe-AO-PAN can effectively catalyze the break of azo bond and aromatic ring in the dye molecular, but can not be reutilized efficiently.

Keywords: Modified PAN, Environmentally friendly heterogeneous photocatalyst, Rhodamine B, Degradation of dye

1. Introduction

At present, the dyeing process wastewater is one of the hard-to-treat industrial wastewaters in China. With the rapid development of the dye and dyeing process industry, the resulted pollution to the environment is on the rise. However, it is hard to process numerous and jumbled dye wastewaters of complex constituents, high chromaticity and high toxicity by physiochemical technology and biotechnology. Now, the widely applied homogeneous photo-assisted Fenton oxidation process has great advantages in treating the hard-to-degrade, harmful and toxic pollutants, and is being taken more seriously by professionals. Homogeneous reactions are chemical reactions in which the reactants, products and catalyst are in the same phase. All reactants and catalysts in the reaction contact with each other sufficiently, and appear higher activity and selectivity, but it is hard to reutilize the catalyst. In homogeneous Fenton reaction, pH is limited in a small range of 2.0~5.5, and large amount of remaining iron ion (as catalyst) in the solution leads to the secondary pollution which increases the process cost of wastewater. Therefore, it is necessary to improve the Fenton reaction system to separate iron ion from the homogenous solution, then absorb iron ion onto the carrier. The formed heterogeneous Fenton reaction system lowers the secondary pollution and the process cost by reutilizing iron ion. In one word, with its strong degradation ability, no secondary pollution, easy-to-recycle catalyst and etc., heterogeneous Fenton technology becomes a hot topic in the environmental protection research.

This paper studied on the preparation of Fe-AO-PAN catalyst applicable to the heterogeneous Fenton system, and investigated its catalytic degradation on the standard target dye Rhodamine B. The results have important and instructive significances to the further studies on the catalytic property of the environmentally friendly Fe-PAN fibrous catalyst, decrease of the environment pollution from dye, as well as realization of the sustainable development.

2. Experiment

2.1 Reagent and dye

PAN yarn, $NH_2OH{\cdot}HCl$, $FeCl_3{\cdot}6H_2O$, NaOH and H_2O_2, commercial analytical reagents; Rhodamine B, a pure dye sample provided by Tianjin Sanhuan Chemical Co., Ltd., whose chemical structure is shown in figure 1.

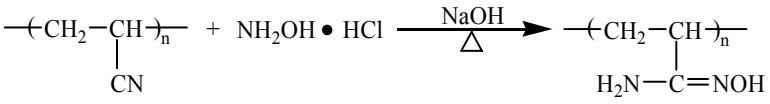
2.2 Experimental instrument

723 spectrophotometer, from Shanghai Analytical Instrument Co., Ltd.; UV-PC2401 ultraviolet-visible light spectrophotometer, from Shimadzu Corporation of Japan; PH-25 digital pH meter, from Shanghai Precision & Scientific Instrument Co., Ltd.; UV-A radiometer and FZ-A radiometer, both from Photoelectric Instrument Factory of Beijing Normal University; AL204 electronic analytical balance, from Mettler-Toledo (Shanghai) Instrument Co., Ltd.; 400 W high-voltage mercury lamp, from Osram (foshan) Co., Ltd.; HZ-1 magnetic stirrer, from Shanghai Secondary Analytical Instrument Co., Ltd.; and water-cooled photochemical reactor, Chinese Utility Model Patents (No. 03275610.0).

2.3 Preparation of Fe-AO-PAN catalyst

2.3.1 Modification of PAN fiber

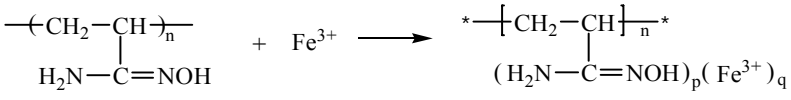
Put accurately weighed PAN yarn into a certain concentration of aqueous solution of NaOH and $NH_2OH{\cdot}HCl$ to obtain a mixture of PAN, $NH_2OH{\cdot}HCl$ and NaOH in the molar ratio of 1.0:1.25:0.75. Stir for 1.5 hours at (70±1) ºC under the conditions of pH 5.5~6.0 to get AO-PAN fiber, take it out and wash with distilled water until pH is close to neutral, then dry it for further use. The reaction equation is as following formula (1).



(1)

2.3.2 Coordination reaction

Dip AO-PAN fiber into a given concentration of $FeCl_3$ solution, mix on the magnetic stirrer at pH 1.5~2.5 for 6 h, then repeatedly wash with distilled water until no detectable chloride ion. The obtained chocolate-brown yarn is dried to get Fe-AO-PAN catalyst. The reaction equation is as following formula (2).



(2)

2.4 Determination of Fe^{3+} content ($C_{Fe\text{-}AO\text{–}PAN}$)

Add a certain quantity of Fe-AO-PAN catalyst into 20 mL 2.0 mol/L H_2SO_4 solution. It is observed that chocolate-brown of the solution gradually turns into white after about 6 h, which indicates that iron ion therein is completely desorbed from catalyst. Determine the concentration of iron ion in the desorption solution by Phenanthroline Method, and calculate $C_{Fe\text{-}AO\text{–}PAN}$ per unit mass.

2.5 Degradation process of dye

Photocatalytic degradation of the dye is carried out in a water-cooled photochemical reactor which is composed of light source (high-voltage mercury lamp and UV lamp), temperature-controlled magnetic stirrer, reactor (special beaker), glass rack and etc. Add 100 mL mixed solution of 0.02 mmol/L dye (unless otherwise specified) and 3.0 mmol/L H_2O_2 into the reactor, regulate to a certain pH, then dip a certain quantity of Fe-AO-PAN catalyst (fixed by winding on the surface of glass rack) into the solution, react at 20±1 ºC in the water-cooled photochemical reactor under a certain radiation intensity controlled by regulating the light source. Unless otherwise specified, the average radiation intensity of UV (365 nm) and visible light (400~1,000 nm), and the illuminance thereof on the surface of the dye solution are respectively 0.49 mW/cm^2, 5.07 mW/cm^2 and 22.1 ×10^3 Lux.

Measure the absorbency of the dye solution at the maximum absorption wavelength with spectrophotometer at regular intervals, and calculate the decoloration rate with the following formula (3).

$$D\ (\%) = (A_0\text{-}A)/A_0 \times 100\% \quad (3)$$

Wherein, A_0 and A respectively represent the initial absorbency and after-reaction absorbency of the dye solution at the maximum absorption wavelength.

3. Result and discussion

3.1 Coordination reaction between AO-PAN fiber and Fe^{3+}

3.1.1 Effects of C_{Fe} on $C_{Fe\text{-}AO\text{–}PAN}$

Dip 1.0 g AO-PAN fibers (*CP*%=60.05%) into $FeCl_3$ solutions of different initial concentrations, react at 20 ºC for a given period to get Fe-AO-PAN catalysts. Figure 2 exhibits the relation between C_{Fe} and $C_{Fe\text{-}AO\text{–}PAN}$.

Figure 2 indicates that $C_{Fe\text{-}AO\text{–}PAN}$ increases with the reaction going on, reaches equilibrium after 120 min, and is saturated after 300 min. It is worth notice that $C_{Fe\text{-}AO\text{–}PAN}$ increases with the rise of C_{Fe} at the equilibrium concentration. It is mainly because that the rise of C_{Fe} increases the contact probability between Fe^{3+} and the surface of AO-PAN fiber,

and speeds up its diffusion into the fiber, in turn accelerates the coordination reaction of Fe^{3+} with amino nitrogen and hydroxyl oxygen in the amidoxime group, finally increases the amount of the fixed Fe^{3+} on the fiber.

3.1.2 Effects of reaction temperature on $C_{Fe\text{-}AO\text{–}PAN}$

Dip 1.0 g AO-PAN fiber (*CP*%=60.05%) into 0.1 mol/L $FeCl_3$ solution, react at different temperatures to get Fe-AO-PAN catalysts. Figure 3 exhibits the relation between the reaction temperature and $C_{Fe\text{-}AO\text{–}PAN}$.

From figure 3, we can see that $C_{Fe\text{-}AO\text{–}PAN}$ increases with the rise of reaction temperature after the same reaction period. It indicates that the rise of reaction temperature helps the coordination reaction between the amidoxime group in AO-PAN fiber and Fe^{3+}, which is probably due to the heat absorption during reaction. In addition, the swelling capacity of PAN fiber increases with the rise of temperature, which not only makes Fe^{3+} much easier to diffuse into the fiber, but also increases the exposure area of amidoxime group. As a result, the reaction probability between Fe^{3+} and amidoxime group increases and leads to the increase of $C_{Fe\text{-}AO\text{–}PAN}$. However, further investigation indicates that the surface of amidoxime fiber shrinkages and turns hard after coordinating with Fe^{3+}, and its mechanical properties reduce, therefore, it is not proper to carry out the coordination reaction at a high temperature.

3.2 Catalytic degradation of Fe-AO-PAN catalyst

3.2.1 Effects of $C_{Fe\text{-}AO\text{–}PAN}$ on catalytic degradation

Under the conditions of pH 6.0 and radiation, add 1 g Fe-AO-PAN catalysts of different $C_{Fe\text{-}AO\text{–}PAN}$ (0.00 mg/g, 30.60 mg/g, 40.46 mg/g, 52.80 mg/g and 62.78 mg/g) respectively into Rhodamine B solutions, and catalytically degrade in the water-cooled photochemical reactor. Figure 4 exhibits the effects of $C_{Fe\text{-}AO\text{–}PAN}$ on decoloration rate.

From figure 4, we can see that even though the decoloration rate increases with the reaction going on when $C_{Fe\text{-}AO\text{–}PAN}$ is zero, it is still less than 15% after 90 minutes' reaction. This slow increase mainly comes from the limited absorption of the dye on PAN fiber. However, decoloration rate of the dye increases markedly when $C_{Fe\text{-}AO\text{–}PAN}$ is up to 30.60 mg/g, and continues to increase with the rise of $C_{Fe\text{-}AO\text{–}PAN}$. This rapid increase is due to the catalysis resulted from the surface unsaturation of Fe-AO-PAN: the rise of $C_{Fe\text{-}AO\text{–}PAN}$ accelerates H_2O_2 to decompose into HO·, and HO· can initiate the chain decomposition reaction, which increases the decoloration rate of the dye.

3.2.2 Effects of radiation intensity on catalytic degradation

Under the conditions of pH 6.0 and in the presence of 0.50 g Fe-AO-PAN catalyst ($C_{Fe\text{-}AO\text{–}PAN}$ = 52.81 mg/g), the catalytic degradation of Rhodamine B is carried out at different radiation intensity in a water-cooled photochemical reactor (Table 1). Figure 5 exhibits the effects of radiation intensity on catalytic degradation.

From figure 5, we can see that the decoloration rate of Rhodamine B increases with the reaction going on, and almost reaches 70% after 70 minutes' reaction without radiation. It indicates that Fe-AO-PAN can catalyze the degradation of the dye even at dark state. However, the decoloration rate of Rhodamine B increases much sharper with the rise of radiation intensity. It indicates that the catalysis of Fe-AO-PAN to oxidation of the dye is closely related to the radiation intensity. This is probably because light radiation helps the dye molecular absorbed on the surface of catalyst to be excited to emit electron, and promotes the cyclic catalytic reaction between Fe^{3+} and Fe^{2+} to produce more HO· (Li, Jing, 2003, p. 2214-2215), in turn accelerates the degradation of the dye.

3.2.3 Effects of dye concentration on catalytic degradation

Under the conditions of pH 6.0 and radiation, separately add 0.5 g Fe-AO-PAN catalysts ($C_{Fe\text{-}AO\text{–}PAN}$ = 28.56 mg/g) into Rhodamine B solutions of different concentrations. Figure 6 exhibits the effects of dye concentration on catalytic degradation.

From figure 6, we can see that the decoloration rate of Rhodamine B decreases with the rise of initial concentration of the dye after the same reaction period. This is probably related to the equilibrium between association and dissociation of the dye in water solution (Zhang, Zhuangyu, 1991, p. 81-82). Namely, association increases and dissociation decreases with the rise of initial concentration of the dye, and the contact probability of the dissociated dye with strong oxidant (HO·) reduces. As a result, the decoloration rate of the dye decreases.

3.2.4 Effects of pH on catalytic degradation

Under the condition of radiation and in the presence of 0.5 g Fe-AO-PAN catalysts ($C_{Fe\text{-}AO\text{–}PAN}$ = 28.56 mg/g), investigate the catalytic degradation of Rhodamine B solutions at different pH. Figure 7 exhibits the effects of pH on catalytic degradation.

Figure 7 indicates that the decoloration rate of the dye increases with the rise of pH in an acid environment, and reaches the maximum at the condition of pH 6.0, however decreases with the rise of pH in a basic environment. This is probably because proton can strongly capture HO· to slow down the degradation of the dye in an acid environment, especially in the solution of pH less than 3.0 (Zhang, Zhuangyu, 1991, p. 81-82). While in a basic environment, iron ion with catalytic activity is susceptible to hydrolysis to form FeOOH precipitation (Feng, J.Y., 2003, p. 2058-2066), and absorbs

large amount of hydroxide ion to inhibit the catalytic activity of itself. In addition, the rise of pH not only affects the absorption of the dye on the surface of catalyst (Zhang, Zhuangyu, 1991, p. 81-82), but also causes the excessive decomposition of H_2O_2 (Zhang, Zhuangyu, 1991, p. 81-82), as a result, the amount of HO· reduces, and leads to the decrease of the decoloration rate of the dye.

3.2.5 Reutilization of Fe-AO-PAN catalyst

In order to investigate the service life of Fe-AO-PAN catalyst, take Fe-AO-PAN out of the solution after degradation ($C_{\text{Fe-AO–PAN}}$ = 52.81 mg/g), repeatedly wash with distilled water, and reuse in a new dye solution, again in a third new dye solution. Figure 8 exhibits the reutilization effect of Fe-AO-PAN catalyst in degrading Rhodamine B.

Figure 8 indicates that the decoloration rate of Fe-AO-PAN catalyst in Rhodamine B solution after 40 minutes' reaction is up to 80% for the first use, lowers to 58% for the second use, and less than 40% for the third use. It proves that the catalytic activity of regenerated Fe-AO-PAN decreases. It can be explained in the following ways: on the one hand, Fe-AO-PAN catalyst is deactivated because its active center (iron ion) absorbs by-product, impurities and other catalyst poisons, and its catalysis on the degradation of the dye decreases or disappears; on the other hand, the surface of regenerated Fe-AO-PAN catalyst, blocked with impurities, can not contact the dye efficiently, and causes the decrease of decoloration rate.

3.2.6 Analysis by UV-visible light spectrum

The structure change of aromatic ring in Rhodamine B is investigated by analyzing its degradation procedure with UV-visible light spectrophotometer. The results are shown in figure 9.

Figure 9 indicates that two characteristic peaks (255 nm and 550 nm) of Rhodamine B become weaker with the reaction going on. By comparing figure 9 (a) with figure 9 (b), we can see that the characteristic peaks disappear much faster with the increase of $C_{\text{Fe-AO–PAN}}$. It indicates that azo bond and aromatic ring in the dye molecular break in the presence of catalyst, and break much faster with the increase of $C_{\text{Fe-AO–PAN}}$. This further proves that Fe-AO-PAN has catalytic activity on both decoloration procedure of Rhodamine B and degradation procedure of molecular structure.

4. Conclusion

(1) Fe-AO-PAN catalyst is prepared with amidoxime modified polyacrylonitrile fiber (AO-PAN) and $FeCl_3$. The content of active center (iron ion) on the surface of catalyst increases with the rise of iron ion concentration in solution, reaction temperature, as well as reaction time.

(2) Fe-AO-PAN catalyst has significant catalytic activity on the degradation of Rhodamine B, and this catalysis increases with the increase of $C_{\text{Fe-AO–PAN}}$.

(3) The increase of the concentration of Rhodamine B solution may cause the decrease of decoloration rate. The catalytic activity of Fe-AO-PAN reaches the maximum at pH 6.0, and decreases whether pH increases or decreases.

(4) Even though Fe-AO-PAN has certain catalytic activity on the degradation of Rhodamine B without light radiation, the radiation intensity shows a significant positive correlation with the catalytic activity of Fe-AO-PAN.

(5) UV-visible light spectrum indicates that Fe-AO-PAN catalyst can effectively break the molecular structure of Rhodamine B, but its reutilization efficiency is not very high and needs further study.

References

Dong, Yongchun, Du, Fang, Ma, Hanxiao, Han, Zhenbang & Cao, Yanan. (2008). Preparation of a Fe-modified polyacrylonitrile fibrous photocatalyst and its application in degradation of Reactive Red MS. *The Chinese Journal of Process Engineering*, 8(2), 359-365.

Feng, J.Y., Hu, X. J., Yue, P. L., Zhu, H. Y. & Lu, G. Q. (2003). Degradation of Azo-Dye Orange II by a photoassisted Fenton reaction using a novel composite of iron oxide and silicate nano-particles as a catalyst. *Industrial & Engineering Chemistry Research*, 42, 2058-2066.

Li, Jing, Ma, Wanhong, Huang, Yingping, Cheng, Mingming, Zhao, Jincai & Yu, Jimmy C. (2003). A highly selective photooxidation approach using O_2 in water catalyzed by iron (Ⅱ) bipyridine complex supported on NaY zeolite. *Chemical Communications*, 2214-2215.

Tao, Tingxian, Wu, Zhichuan & Zhao, Zeqing. (2001). Preparation of chelating fibers: modification of polyacrylonitrile fiber. *Synthetic Fiber in China*, 30(4), 32-42.

V. V. Ishtchenko, K. D. Huddersman & R. F. Vitkovskaya. (2003). Production of a modified PAN fibrous catalyst and its optimisation towards the decomposition of hydrogen peroxide. *Applied Catalysis*, 242, 123-137.

Zhang, Zhuangyu & Wu, Zuwang. (1991). *Application of Dye*. Beijing: Chemical Industry Press, p. 81-82.

Table 1. Four different radiation intensities

Radiation light	UV (365 nm) / mW·cm^{-2}	Visible light (400~1,000 nm) / mW·cm^{-2}	Illuminance / Lux
(A)	0.00	0.001	1.8
(B)	0.38	1.58	5.11×10^3
(C)	0.49	5.07	22.1×10^3
(D)	0.99	9.38	27.4×10^3

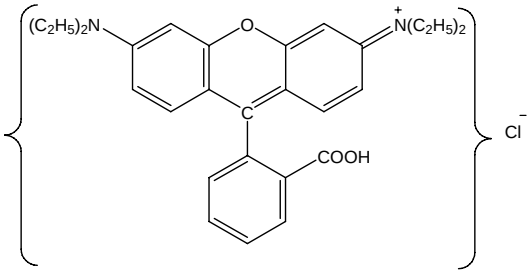


Figure 1. Chemical structure of Rhodamine B

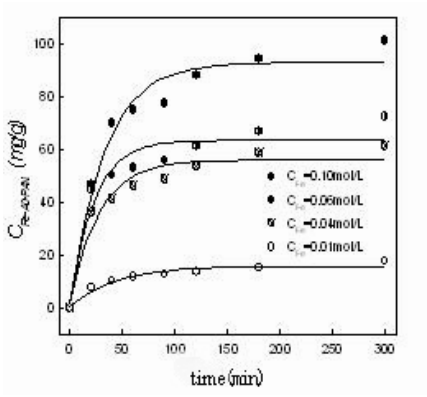


Figure 2. The effect of C_{Fe} on $C_{Fe\text{-}AO\text{–}PAN}$

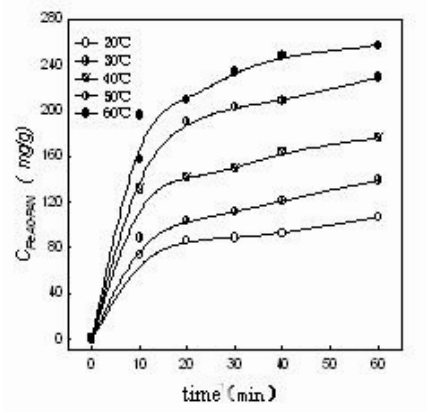


Figure 3. The effect of reaction temperature on $C_{Fe\text{-}AO\text{–}PAN}$

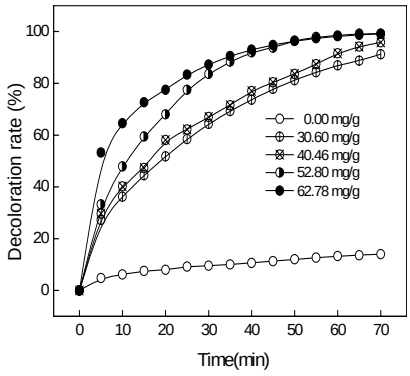


Figure 4. The effects of $C_{\text{Fe-AO–PAN}}$ on catalytic degradation

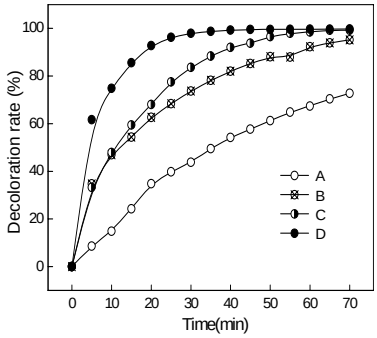


Figure 5. The effects of radiation intensity on catalytic degradation

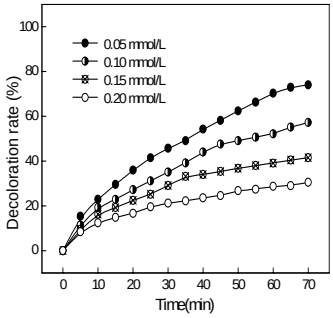


Figure 6. The effects of dye concentration on catalytic degradation

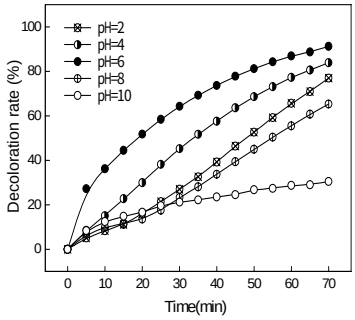


Figure 7. The effects of pH on catalytic degradation

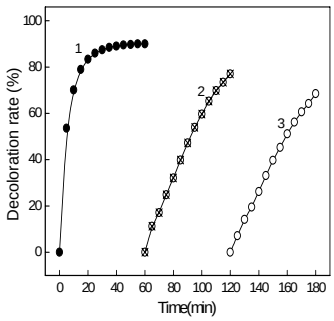
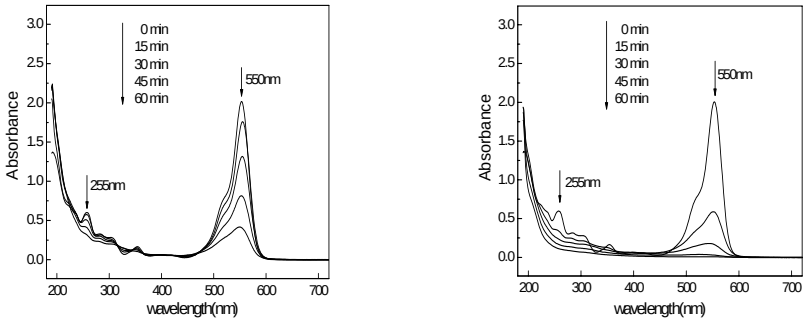


Figure 8. Reutilization of Fe-AO-PAN catalyst



(a) $C_{\text{Fe-AO–PAN}} = 28.56$ mg/g (b) $C_{\text{Fe-AO–PAN}} = 86.41$ mg/g

Figure 9. UV-visible light spectrum of degradation of Rhodamine B

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Design of Temporary Storage of Municipal Solid Waste and Its Impact on Global Warming –A Case Study

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Abstract

Municipal Solid Waste (MSW) Management continues to remain as one of the most challenging task in urban development. Despite the fact that the core environmental impact is linked to the emissions of landfill gases of MSW, the production of collection bins for Temporary Storage (TS) of MSW, also makes a substantial contribution to environmental impact. This paper presents a methodology to estimate the amount of emissions produced during the production of High Density Poly Ethylene (HDPE) collection bins. The MSW collection bins required is evaluated based on bin size, population, percapita solid waste generation and collection frequency. In this paper, the number and size of MSW collection bins, bin density and catchment area for various collection frequency for Coimbatore city is designed with the environmental impact indicator-Global Warming Potential (GWP) based on the predicted waste generation for a decade (2008-2017). This long term predictions could be useful to waste management organizers to select sound environmental management strategies.

Keywords: Collection bins, Emissions, Environmental impact, Global warming potential, Municipal Solid Waste, Temporary storage

1. Introduction

In many countries, environmental issues on Municipal Solid Waste (MSW) management decisions are prime concern for environmentalists and decision makers in government agencies. Among the driving force of these issues, is threat to global climate change. The climate change is the serious international environmental concern and subject of much research. Many scientists are alarmed by a significant increase in the concentration of Carbon dioxide (CO_2) and other green house gases (GHG) in the atmosphere. Since the pre industrial era, atmospheric concentrations of CO_2 have increased by nearly thirty percent and Methane (CH_4) concentrations have more than doubled (**Mccarthy J.J 2001**). By addressing a broader set of MSW management options, a more comprehensive picture of GHG emissions in the waste sector is determined and the relative GHG in waste management could be assessed. One way of reducing emissions of GHG, from the MSW management is to understand and choose environmentally sound MSW management options.

In India, the production of solid waste per person is 500 g per day in urban areas **(CPCB 2000)**. The solid waste generation varies from town to town depending upon the density of population. The rate of solid waste generation depends on various factors namely population density, existing commercial and industrial activities, life style and climatic conditions etc. The report of high power committee on urban solid waste management in India reported that system of segregation of organic, inorganic and recyclable wastes at household levels is not implemented (**Planning commission, 1998**). Further, the disposal of MSW is by unplanned and uncontrolled open dumping at the landfill sites.

The collection bins act as Temporary Storage (TS) for MSW generated from the household. The stage of TS is the point where waste leaves the house and enters waste management system. The input is based on source sorted waste materials, which have estimated. Output is different waste materials that are stored in bins. It has to be noted that TS as a contact point between waste generators and waste management system should be carefully managed (**Darmstadt et al, 2005**). The waste management systems that fail to receive balance in this relationship are unlikely to succeed.

A limited research work has been reported in literature about the design of TS. Hence, it is planned to take systematic work to estimate the size and number of bins with different collection frequencies. The design of TS should be integrated with other MSW management options to abate degradation in urban environment. The production of galvanized steel MSW collection bins of 1100 litres (L) volume leads to the threefold higher impact on global warming and twenty-three fold higher human toxicity than same size of High Density Poly Ethylene (HDPE)(**McDougall et al, 2001**).Hence collection bins of HDPE material is considered in this study.

The design of TS for MSW can be accomplished through promotion of economically efficient and environmentally sound design options. The short-term predictions on generation of MSW for the design TS can facilitates better understanding with respect to collection, transport and final disposal of MSW. However, long term forecasting could be very useful to waste management organizers to select appropriate design strategies. To assess environmental impact in the design of TS, the impact indicator-Global Warming Potential (GWP) is considered. In this paper, GWP is assessed in the design of TS for a decade (2008-2017) for Coimbatore city, India. The assessment of GWP helps to select the suitable design of TS for MSW by responsible decision makers.

2. Study area characteristics- Coimbatore City

2.1 General

Coimbatore city is situated in south India, has around 11º North latitude, 77º East longitude and 432.0m above mean sea level, while the city is flat, it is surrounded by hilly terrain, since it is situated at the foot of Nilgiri hills. As it is exposed to the palghat gap of Westernghats, it enjoys a salubrious climate throughout the year. The maximum temperature observed in this city is 34º C and minimum temperature is 20ºC. April and May are hottest months in the city. This city has an average rainfall of 60 cm.

2.2 Source wise generation of MSW

The MSW is collected from all the places of city such as domestic, industries, markets, marriage halls, street sweeping, hotels, and restaurants. The Figure 1 shows the quantity of wastes generated from various sources of the city. It is estimated that 564 tons of MSW generated from the above sources in a day in the city. The wastes generated from the residential sources account for more volume of the total wastes.

2.3 Population and rate of waste generation

The city has a population of 10, 93,888 spread over an area of 105 km^2. The quantity of zone wise waste generation of MSW and the corresponding population statistics are given in Table1. (**Commissioner of Municipal Administration, India, 2004**). The per capita solid waste generation by Coimbatore dwellers is 516 g per day.

2.4 Material composition of waste

The wastes disposed by the residents are organic in nature (76.95%) and the initial moisture content of organic waste is high (57%). The construction and demolition wastes are not included in the calculation of waste generation. The default values for material composition of waste fractions of MSW are given in Table 2.

2.5 Municipal administration

The entire Coimbatore city is divided into four zones viz North, South, East and West. Each zone has 18 wards. The respective authorities in the different levels monitor MSW management of primary collection, secondary collection and overall activities.

2.6 Methods of storage

At present Coimbatore Municipal Corporation (CMC) has provided 1000L HDPE containers for temporary storage of MSW, which are at specific locations for the residents to dispose the wastes. The bin has top lids for covering the wastes and bottom wheels for moving the bins. In most of the places of the city, adequate numbers of bins are not placed for the disposal of wastes for the residents. Stationary Container Systems (SCS) are used for the disposal of

wastes. Old types of bins are in concrete and most of the bins are damaged. The wastes are thrown and heaped in streets as dumping points. At present only mixed wastes are collected from the city.

2.7 Primary collection of MSW

Both Corporation vehicles and Private vehicles are employed to collect the wastes from the roadside dumping points and HDPE bins. Thirty to forty percent of the waste is left uncollected in streets and part of the waste is disposed by open burning. This is due to the non-availability of the sufficient transportation of fleet, frequent breakdown of vehicles and absenteeism of the crew. House to house collection of solid waste is not practiced in the city. However, in some areas, the welfare association and societies have arranged for house-to-house collection of solid waste on specified monthly payments. The municipal bodies are still facing increasingly serious problems for the collection of wastes due to generation of the huge quantity of MSW. However, hospitals are expected to manage their own wastes.

2.8 Secondary collection/transportation of MSW

In the city, the western and southern zones of wastes are collected and transferred to the disposal site through the transfer stations at Ukkadam. The eastern and the northern zone MSW is directly hauled by the collection vehicle from the collection point to the disposal site. Table 3 potrays to the total number of owned and hired vehicles used for the purpose of primary collection and secondary collection / transportation of MSW to the dumping yard of city. It is inferred from the Table 4 that more number of diesel vehicles are used for carrying the MSW.

2.9 Present status of disposal of MSW

The wastes are collected through open body trucks and are dumped in the recognized open dumping site at Vellalure i.e. unsanitary landfills. Since the disposal site is within 15 to 20km of the collection points, transfer stations are not in use. Previously there were four various transfer stations at Peelamedu, Ondipudur, Sathy Road and Ukkadam. Now only one transfer station at Ukkadam is in use. The disposal site in Vellalure covers an area about 604 acres. Since the wastes are disposed off as crude open dumping, this attracts flies, birds, insects and dogs for breeding. It also leads to odour menace in the neighborhood areas. Often the wastes are burnt to reduce the volume, leading to fire and smoke hazards, which causes air pollution. The emission load of pollutants due to open burning of MSW for the state of Tamilnadu (Coimbatore) is growing at the rate of 3 tons/year **[Chnahi Sinha, 1997].** At present unauthorized rag pickers are involved in the collection of recyclable fractions from the different parts of the city and in the open dumping yard. There are also problems of soil and ground water contamination due to leaching of particles of solid waste caused by surface water and rainfall.

2.10 Proposed treatment yards

The CMC is planning to involve private entrepreneurs to deal with the problem of solid waste management. In this regard, the corporation is planning to supply biodegradable wastes of 100 tones per day and non-biodegradable wastes of 30 tons per day for the composting plant and recyclable yard respectively to the private entrepreneurs. Hundred acres of land is designed to provide an integrated facility for processing, composting and recycling. Proposed recycling yard is at Ukkadam and composting yard at Vellalure. At present composting plant of 100 tons per day capacity (Expandable) and land filling in the adjoining areas at Vellalure is proposed.The proposal is under progress.

Recycling solid waste is an attractive strategy for governing officials because of its potential to reduce disposal costs, conserve available landfill capacity and contribute to national goals of energy and resource conservation **[David.H.Folz,1991].** Institutional weakness, lack of financial resources, inappropriate technologies, occupational health hazard, lack of community participation, waste pickers and their associated problems and political interference are the constraints for the effective implementation of the solid waste management programme **[Santhose Mandal,1998].**

2.11 Proposed action plan submitted to the Supreme Court

With the view of proper disposal of MSW, the CMC has submitted the following action plan to the Supreme Court.

- Organising awareness programme Segregation, Reduction, Reuse and Recycling of the wastes.
- Arrangements to collect degradable and recyclable wastes separately by placing adequate number of two bins in the city.
- Waste collection in bin should be cleared regularly to the disposal site.
- Wastes are to be transported under covered conditions and should not be scattered and spilled during transportation.
- For the proper disposal of MSW, Composting yard for degradable waste, Land filling arrangements for inert and Recycling yard for recyclable waste are to be provided and maintained properly.

3. Materials and methods

The main objective of this research paper is to design TS and evaluate GHG emissions due to the use of HDPE collection bins in terms of GWP. The direct environmental impacts are due to the emissions of the GHG during bin production. The size and number of collection bins are included in the model developed for predicting the GHG emissions. In the modeling, the production of main material used for bin production is considered and the raw material manufacturing processes are not included. For the recycling process, it was assumed that the used containers can be partly recycled into secondary materials. The recycled material along with virgin material is used for bin production, reduces the lower net material consumptions. The emissions from production of collection bins are classified and characterized using the Life Cycle Analysis (LCA) methodology.

3.1 Design aspects of the model

This design of TS has been carried out using theoretical considerations and equations considering various parameters. Standard modules included in the design of TS of MSW are

- Size of bin
- Collection frequency
- Average filling rate
- Number of bins
- Volume of material needed for bin production
- Bin density and
- Catchment area

In the design of TS, municipalities have different options for the selection of number of bins, bin size and collection frequency. The different sizes of bins are considered for degradable and recyclable wastes which mainly depends on the quantity of waste generated and bulk density of the waste fractions. Generally, not all the bins are fully filled every time. The filling of bins should be over 50% and under 100% to account for seasonal influences. This value is assumed equal for both waste fractions in the city .The average filling rates of both the bins are assumed as 80%.

3.2 Impact Analysis

The emissions accounted in the design of TS are arranged into environmental impact categories such as GWP. GWP is used as characterization factors to assess and aggregate the interventions for the impact category on climate change. GWP is an index for estimating relative global warming contribution due to atmospheric emission of a kg of a particular GHG compared to emission of a kg of Carbon dioxide (CO_2). Within each impact category, each emission is multiplied by an equivalency factor to obtain an impact potential value. In the production of bins GHG such as Carbon dioxide (CO_2) and Methane (CH_4) are two air emissions considered to calculate GWP. The Methane GWP includes an indirect contribution from stratospheric water (H_2O) and Ozone (O_3) production. Life time values for methane are adjustment times, which incorporate the indirect effects of emission of each gas on its lifetime. The impact category, their respective emissions and equivalency impact factor applied in this study are based on the report from inter governmental panel on climate change **(IPCC, 2001).**

4. Results and discussion

In order to plan the most appropriate type of waste management system, it is essential to collect reliable information about quantities of waste produced, types and amount of material to be reused or recycled. Future community trends such as population growth and waste characteristics profile should be evaluated to determine appropriate management technique. The waste prognosis is mainly based on the income level, life style, population growth, life expectancy rate and mortality rate of the people in the city. The generation rates estimated so far in various cities are only approximate and an accurate and scientific method of estimating the same is still a complex task for the researchers. Hence in this paper, the waste is predicted based on the per capita solid waste and population growth of the city. Figures 2 and 3 shows the total quantity of wastes generated by the Coimbatore dwellers for degradable and recyclable wastes respectively upto the year 2020.

4.1 Size, number and collection frequency of collection bins

The standard sizes of available HDPE collection bins 80, 120, 240, 660, 770, 1100 and 2500L are considered for evaluating the design options of TS. Size of the bin depends on the quantity of the waste generation, bulk density of the wastes and collection frequency. The numbers of bins are estimated for various collection frequencies of once in a month (12 trips per year), once in two weeks (26 trips per year), Four trips in a month (48 trips per year), once in a week (52 trips per year)) and twice in a week (104 trips per year) for both the degradable and recyclable wastes. The numbers of needed bins for size of 80L and 2500L for degradable wastes with collection frequency of once in a month

are 15, 39,049 and 49,250 respectively. The number of needed degradable bins for size of 80L and 2500L with collection frequency of twice in a week is 17,7,580 and 5,690 respectively. The number of estimated recyclable bins for size of 80L and 2500L with collection frequency of once in a month is 29,2,420 and 9,440 respectively. The number of needed recyclable bins for size of 80L and 2500L with collection frequency of twice in a week is 34,035 and 1089 respectively. This is for the present year 2008. This dramatic difference in the total number of bins for both waste fractions are due to the increasing the collection frequency of wastes from monthly once to twice in a week. Also larger size of bin demands, lesser number of bins for the collection of wastes. Higher collection frequency increases the total number of bins with the increase in bin size. Figure 4 and 5 gives the relation between the number and size of bins for various collection frequencies for projected years for both waste fractions.

4.2 Bin density for collection bins

The bin density (number of persons per bin) for various sizes and collection frequencies are calculated for both degradable and recyclable waste fractions. Figure 6 and 7 predicts the relation between bin density and size of bin for various collection frequencies for both degradable and recyclable waste fractions respectively. Bin density of degradable bins of 1100L and 2500L with collection frequency of once in two weeks and twice in a week are 32, 73 and 130, 292 respectively. Therefore, bin density increases with collection frequencies and decreases with the size of bin. It indicates that number of persons used per bin is high because of increase in the size of bin. It is known from the figure 6 that the numbers of persons per bin varies from minimum of one person per bin to maximum of three hundred persons per bin.

Bin density of recyclable bins of 1100L and 2500L with collection frequency of once in two weeks and twice in a week are 156, 354 and 625, 1420 respectively. Thus, bin density of recyclable bin is increased to twenty percentage higher compared to the bin density of degradable bin. This is due to lesser generation of the recyclable waste fraction.

4.3 Catchment area for collection bins

The catchment areas in hectare (ha) per bin are calculated for various sizes and collection frequencies for both collection bins. Figure 8 and 9 shows the catchment areas for various collection frequencies for degradable and recyclable waste fractions respectively. As the collection frequency increases, the catchment area also increases with increase in size of bin. This implies that the number of bins per ha is less because of increase in size of bin. Lesser catchment area needs more number of lesser size bins. This facilitates stoppage of the collection vehicle more frequently and leads to more of vehicle pollution. In addition, more number of lesser size bins is not recommended due to non-entry of collection vehicle in narrow streets of the city.

4.4 Analysis of GWP on design of TS for MSW

The design of the TS for CBE is environmentally assessed using the GWP. GWP decreases as the collection frequency increases and size of the bin decreases. This is due to use of lesser number of bins with the increasing collection frequency. Figure 10 and 11 shows the relationship between GWP, number of bins for various sizes for degradable and recyclable waste fractions. The recommended size of bins for the degradable waste is 1100L and 2500L because of the more generation of degradable waste. The collection frequencies recommended for the degradable wastes are either once in a week or twice in a week because it starts decomposes at a shorter interval of time, which leads to severe problems in handling and poses bad odour.

With the recommended sizes of bin and collection frequencies for degradable wastes, the suitable bin size and collection frequency of recyclable wastes are chosen keeping the total number of bins as same for the both waste fractions. Thus, four cases for design of TS are recommended and shown in Table 4. The estimated total numbers of bins are for the present year 2008. Depends on the population density, the total number of same size of bins can be increased in every year The total percentage increase in the number of collection bins for ten year is 13% for all the four cases for both waste fractions. Since the life period of the bin is ten years , the replacement of the bin is not necessary for every year. The collection frequency may be based on the available collection vehicles. As population grows, the corresponding generated wastes will increase which increases collection frequency per year. In all above four cases, total the numbers of bins increased every year are same for both waste fractions. This ensures the bins can be placed adjacent to each other for easy disposal of waste for the dwellers. In addition, it is convenient for the citizens to dispose the wastes separately and facilitates complete collection of wastes by collection vehicles. Lesser collection frequency leads to lesser vehicular pollution during collection of wastes. Number of persons per bin for all the above four cases are 68,163,128 and 292 respectively for both fractions (Figure 12). The recommended catchment area for the selected four cases of design options of TS varies from 5 to 23 ha per bin (Figure 13)

The total GWP is analysed for the above four cases and are shown in Figure 14. In case I, the collection frequencies are once in week for both the waste fractions. The same collection frequency for both wastes ensures that either separate or two compartmental vehicles can be used for the collection of wastes. The total GWP during the production of the bins in Case I, Case II, increases 50 % and 41 % respectively with respect to Case III. In case III ,though the GWP is 0.03%

higher than the case IV, but the collection frequency of degradable waste and recyclable waste are once in a week and once in a month respectively. There is lesser GWP during the production of the bins in Case IV, with the collection of degradable waste is twice in a week and recyclable waste is Four trips in a month . Based on the lesser environment impact of GWP, the total number bins can be recommended. However, the collection frequency also has an impact during collection and transport of MSW. Therefore, it has to be analyzed for overall environment impact. Based on the available number of vehicles in CMC, the design of MSW can be selected.

5. Conclusions

For easy disposal of waste, both the bins are placed at same location. It depends on the types of dwelling or commercial and industrial facilities, available space and assess to the collection vehicles. Here SCS are recommended, i.e. it remains at the point of generation. This also ensures the complete collection of the waste fractions by the vehicles. Bins are recommended to be placed at the corner of the each street, for the easy accessibility of the vehicle. The collection frequency varies every year based on the quantum waste generated in each year. In addition, these are decided by the Municipalities based the available number of vehicles. This study is useful to the decision makers in MSW management to choose sound environmental management system. The community awareness in the segregation of the waste fraction ensures the successful implementation of this system.

References

Chnahi Sinha. (1997). Open burning of urban municipal solid waste; State level analysis Teri- Information monitor on Environmental Science, Vol. 2, No 2, 71-77.

Commissioner of Municipal Administration. (2000). Action Plan for Implementation of Municipal Solid Waste Management and Handling Rules 2000. Prepared as per the Guidelines, India.

CPCB. (2000). Status of Municipal Solid Waste Generation , Collection,Treatment and Disposal in Class I Cities, Central Pollution Control Board , New Delhi.

Darmstadt (TUD) Emilia den Boer (Szpadt), Jan den Boer, Johannes Jager Darmstadt. (2005). The Use of Life Cycle Assessment Tool for the Development of Integrated Waste Management Strategies for Cities and Regions with Rapid Growing Economies-IWM, Technische Universitaet.

David .H. Folz. (1991). Recycling program Design, Management participation, National survey of Municipal Experience, Public Administration Review, May-June, Vol. 51,No-3, pp 222-235.

Inter governmental panel on climate change. (IPCC). Third assessment report, 2001.

Mccarthy. J.J.,eds. (2001). Climate change, Impacts, Adoptation and Vulnerability, IPCC, Cambridge University press 9-13.

McDougall, F., White, P., Franke, M. and Hindle, P. (2001). Integrated Solid Waste Management: a Life Cycle Inventory, Blackwell Science Ltd, Oxford.

Planning commission, (1998). Report of high power committee: Urban solid waste management in India, New Delhi, Government of India, pp 58.

Santhose Mandal. (1998). Solid Waste Management in the Municipal Towns of Calcutta, Metropolitan Area, Problems of Possible Solutions, Centre of study of Environment, Annual Volume (9) pp 69-74.

Table 1. Zone wise of Generation of Solid Waste and Population

Sl.No	Zone	Number of Houses	Population	MSW Generated in Tons / Day			
				Degradable	Recyclable	Inert	Total
1	East	63,355	2,87,553	102	7.2	22.4	131.6
2	West	59,838	2,66,717	114.4	7.9	21.4	143.7
3	South	46,509	2,38,571	120.4	8.1	19.1	147.6
4	North	59,007	3,01,047	109.4	7.8	23.9	141.1
TOTAL		2,28,709	10,93,888	446.2	31.0	86.8	564.0

Table 2. Material compositions of waste fractions in household waste

Waste Fraction	Waste Materials	Material Contribution Percentage by weight
Degradable	Organic / Biomass	63.70%
	Woody Biomass	12.0 %
	Paper	1.25 %
Recyclable	Plastic	2.20 %
	Glass	0.25 %
	Metal	0.35 %
	Rubber	1.20 %
	Rags / Textiles	1.00 %
	Leather	0.50 %
	Thermocole	0.05 %
Inert	Stones-	5.50 %
	Sand/earth	12.0 %
	Construction debris	Not considered

Table 3. Vehicles used for Collection and Transportation of MSW

S.No	Type of vehicles	Total number of vehicles
Corporation vehicles		
1	Lorries with tipper	9
2	Lorries with non tipper	3
3	Dumper placers	17
4	Bulk Refuse carrier	2
Private vehicles		
5	Hired private lorries	49

Table 4. Recommended design options of TS for MSW (Year 2008)
(D=Degradable waste, R=Recyclable waste)

Size of the bin in L	**Collection frequency**	**Required Number of bins**
Case I		
1100 (D)	Once in a week	26000
240 (R)	Once in a week	26000
Case II		
2500(D)	Once in a week	11500
2500(R)	Once in a month	11500
Case III		
1,100(D)	Twice in a week	13000
240(R)	Twice in a week	13000
Case VI		
2500(D)	Twice in a week	6000
1100 (R)	Four trips in a month	6000

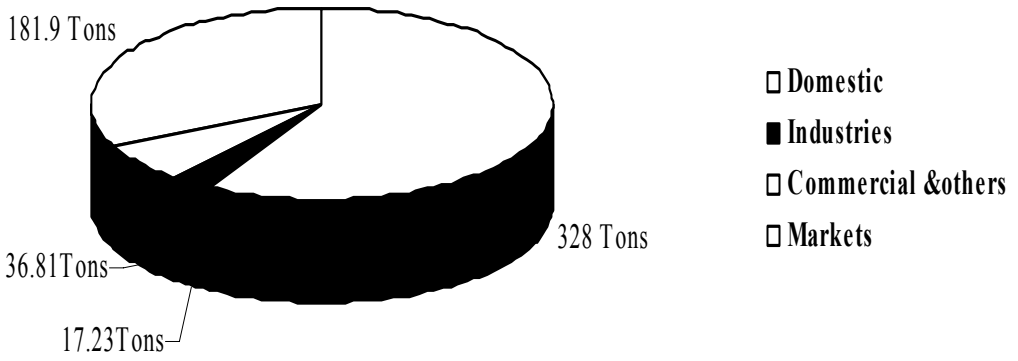

Figure 1. Source wise MSW generation

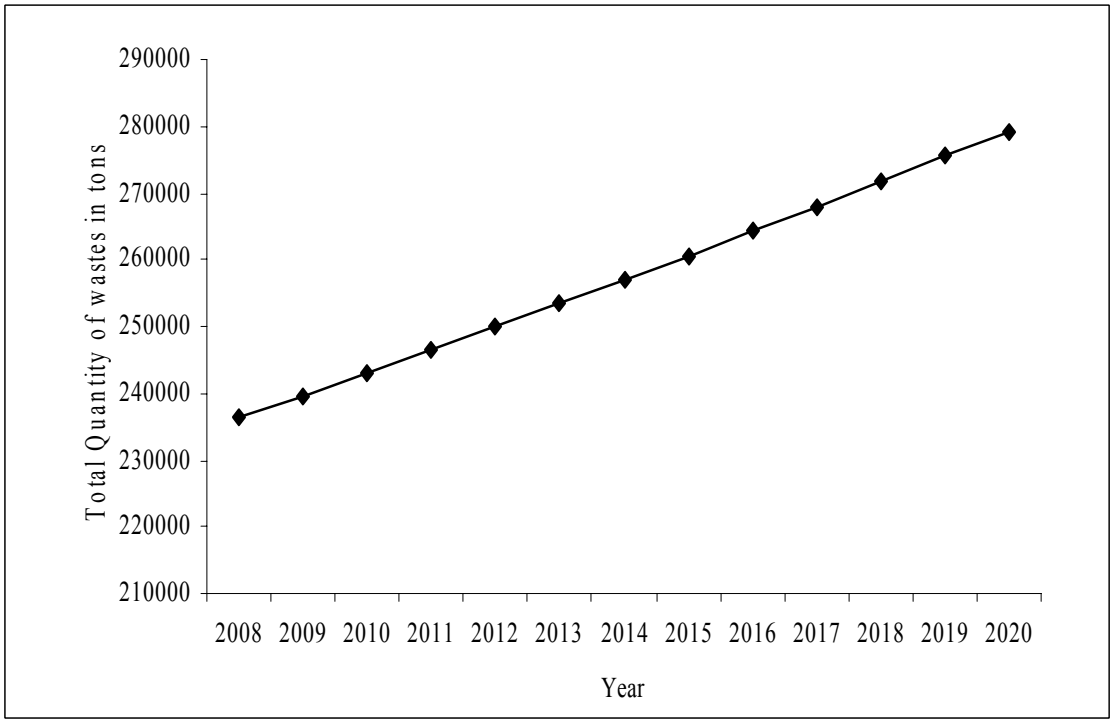

Figure 2. Generation of total quantity of degradable waste

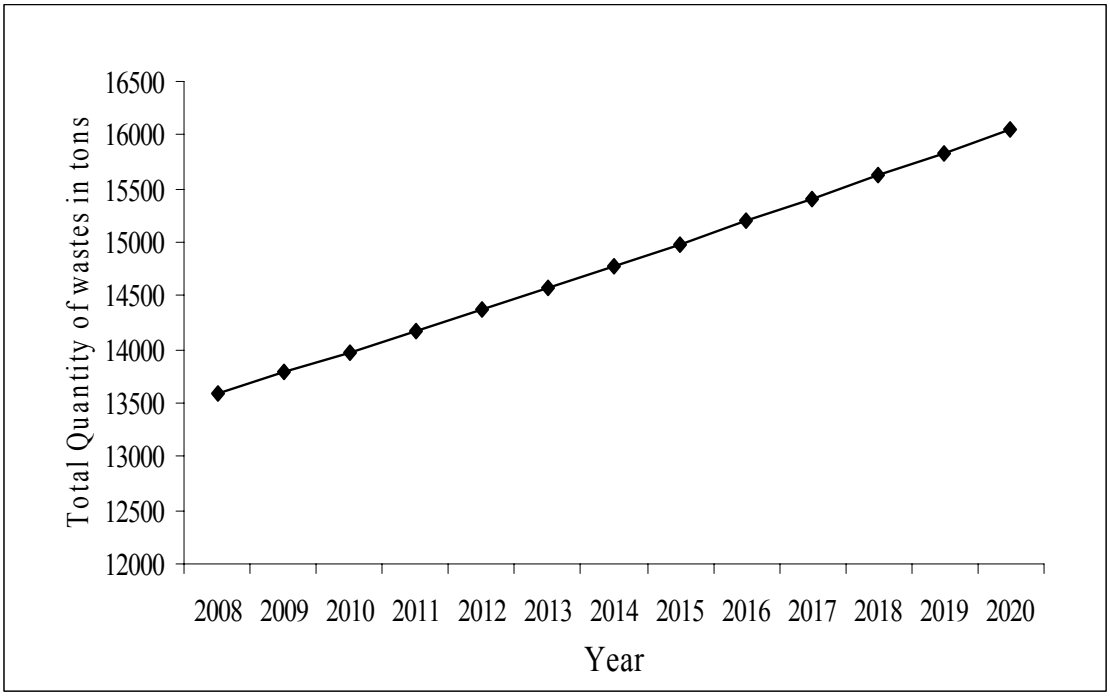

Figure 3. Generation of total quantity of recyclable waste

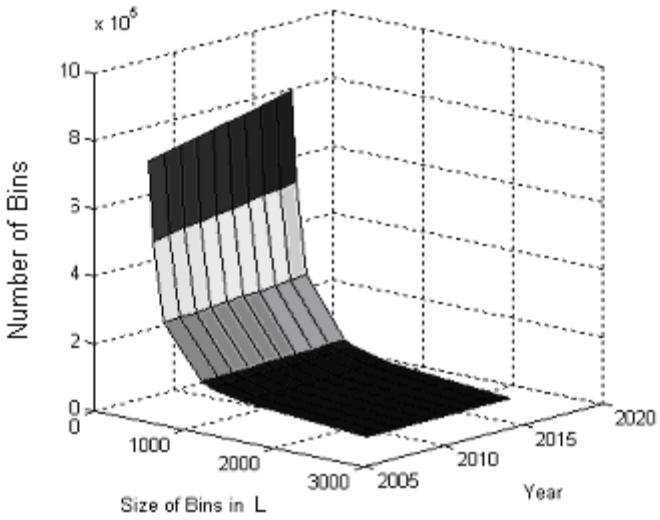

Figure 4. Number and Size of bins for degradable wastes in collection frequency of once in two weeks

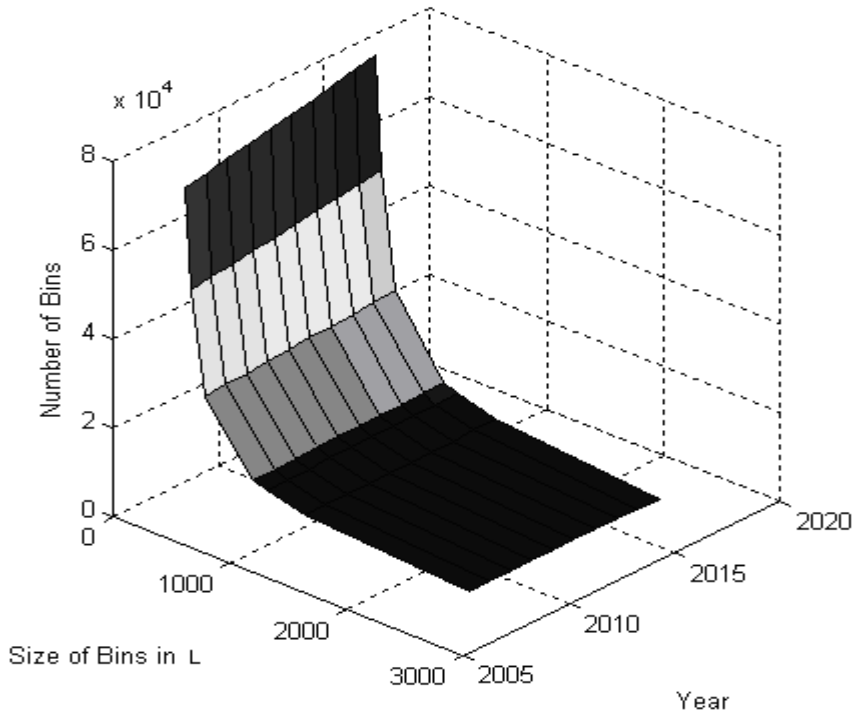

Figure 5. Number and Size of bins for recyclable wastes in collection frequency of once in a week

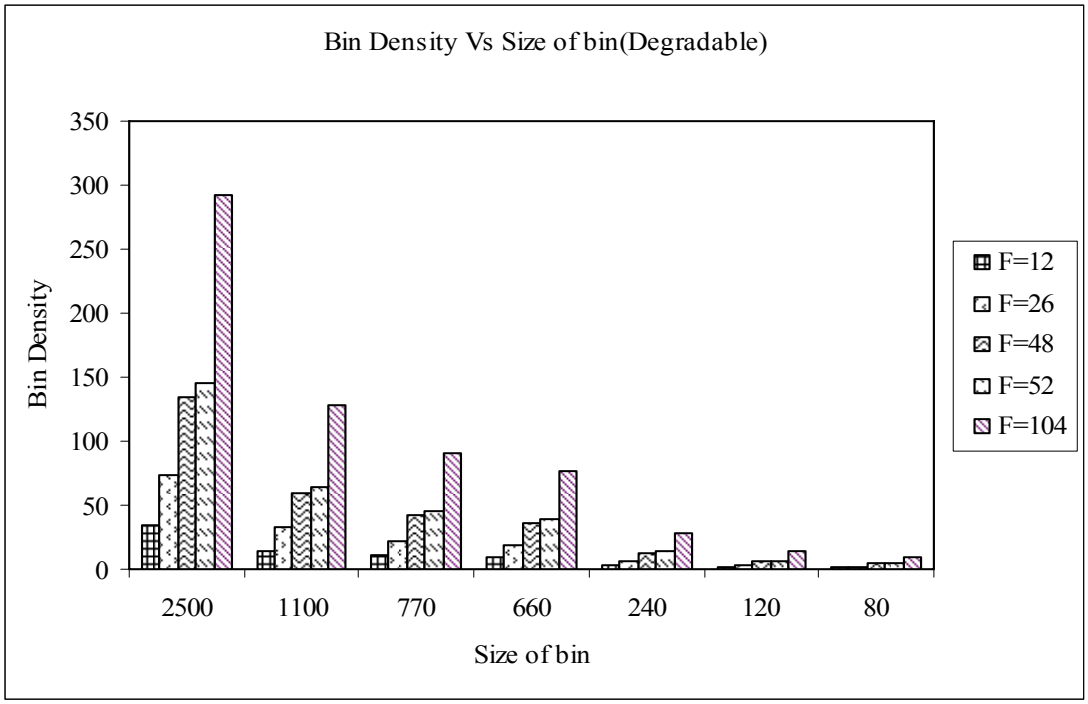

Figure 6. Bin Density and Size of degradable waste bins for various collection frequencies

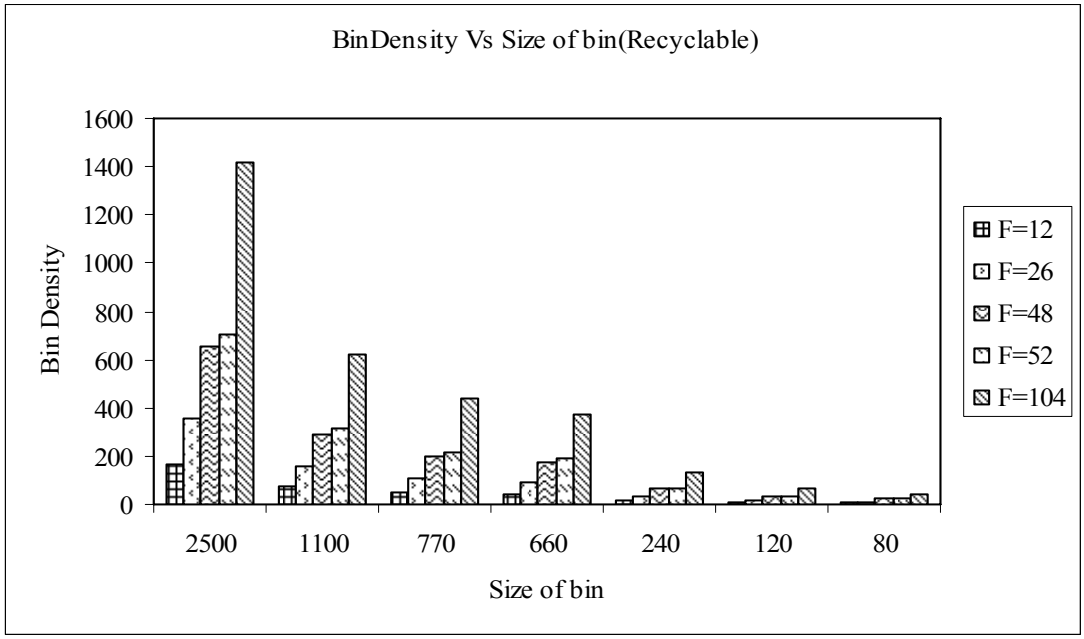

Figure 7. Bin Density and Size of recyclable waste bins for various collection frequencies

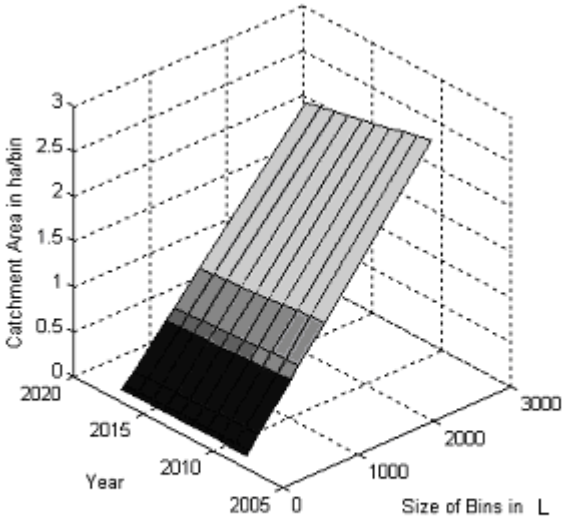

Figure 8. Catchment areas for degradable collection bins at the collection frequency of once in a month

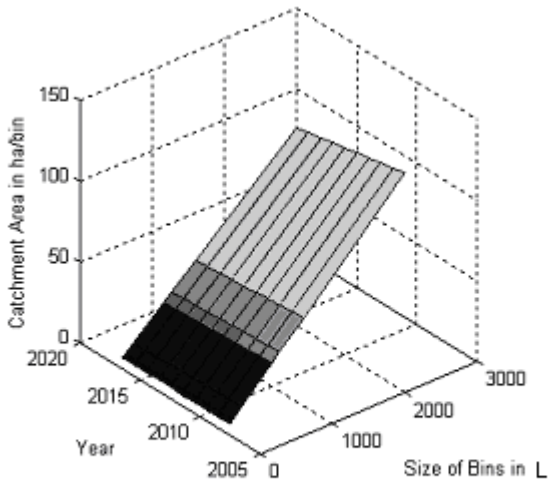

Figure 9. Catchment areas for recyclable collection bins at the collection frequency of twice in a week

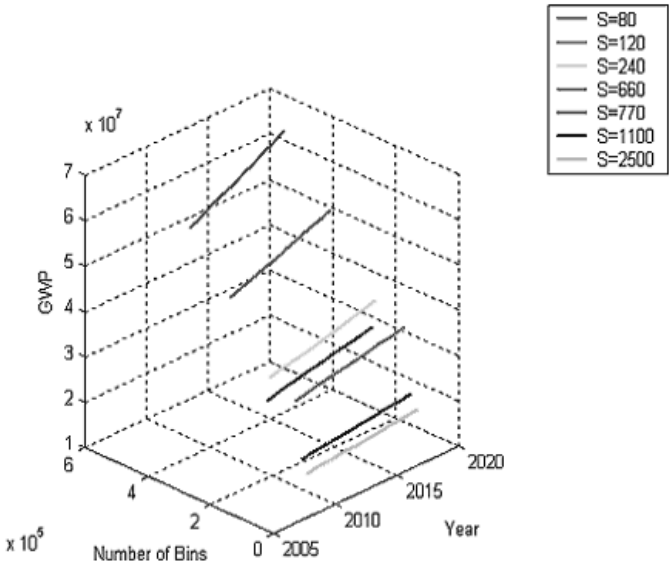

Figure 10. GWP and number of degradable bins for various bin sizes in a collection frequency of four trips in a month

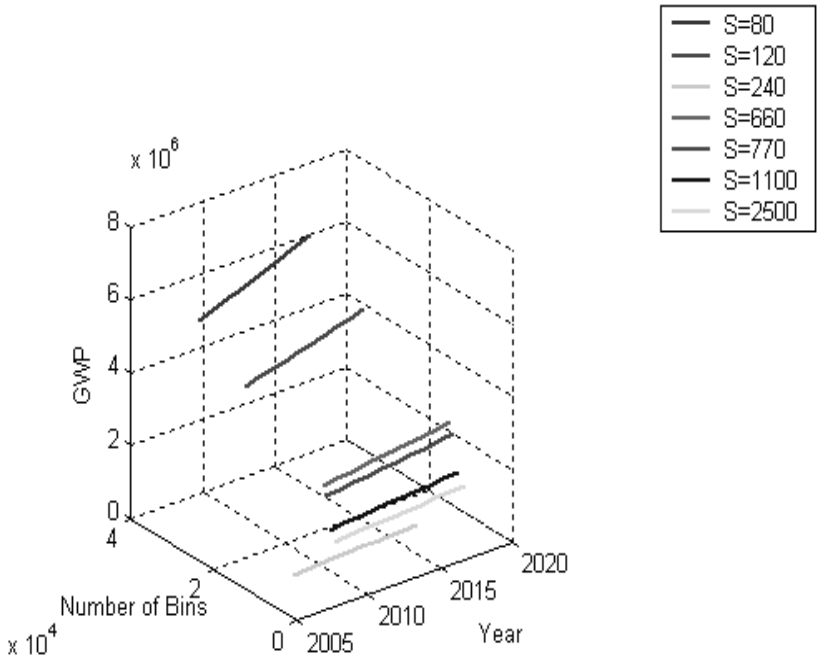

Figure 11. GWP and Number of recyclable bins for various bin sizes in a collection frequency of once in a month

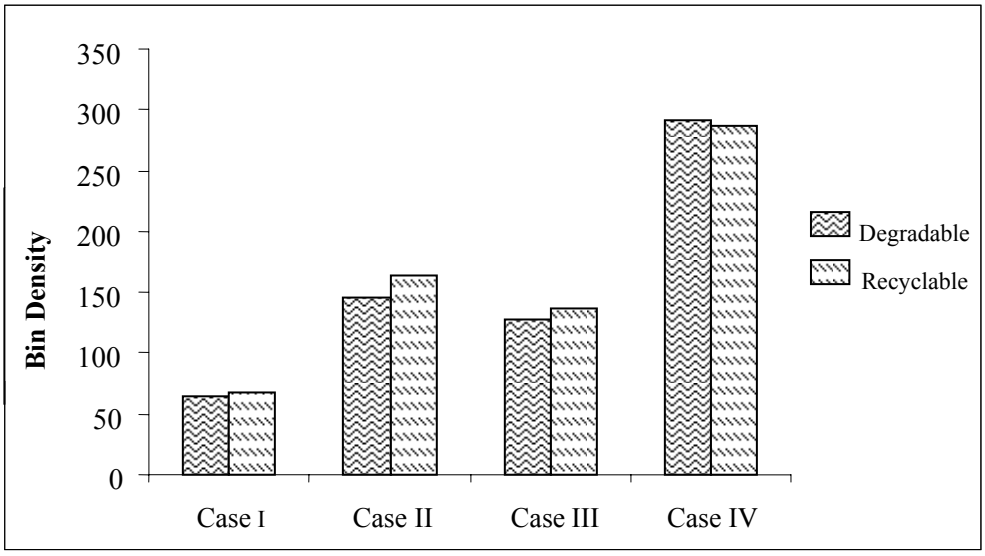

Figure 12. Bin density for recommended options of design of TS

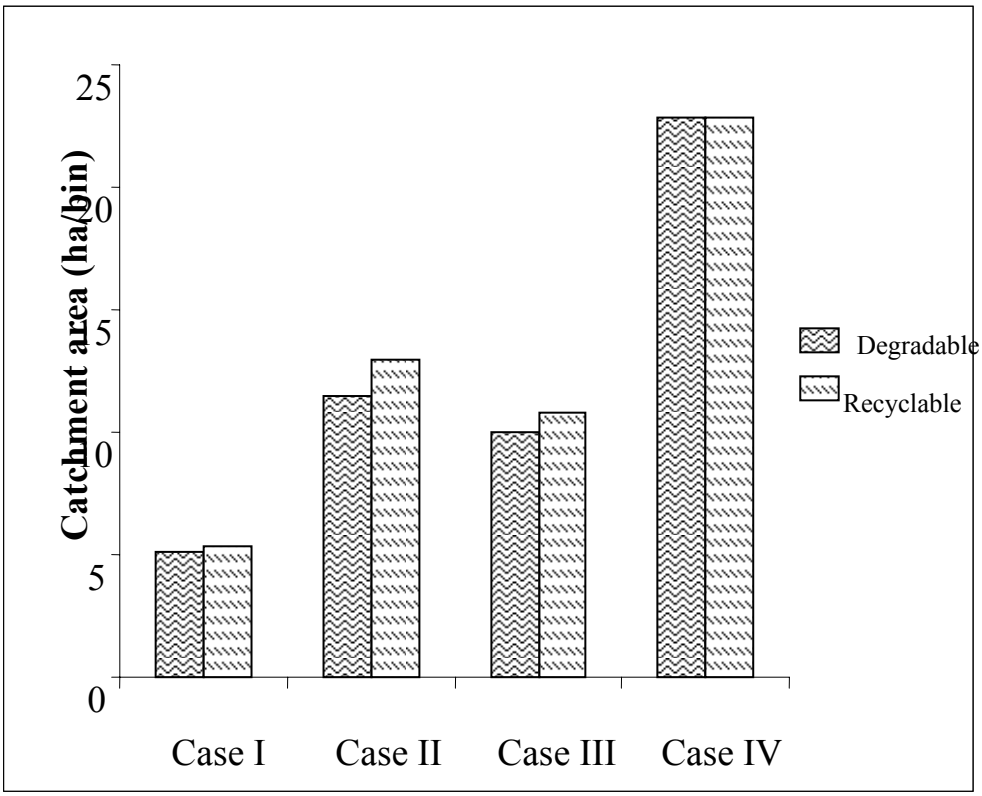

Figure 13. Catchment area for recommended options of design of TS

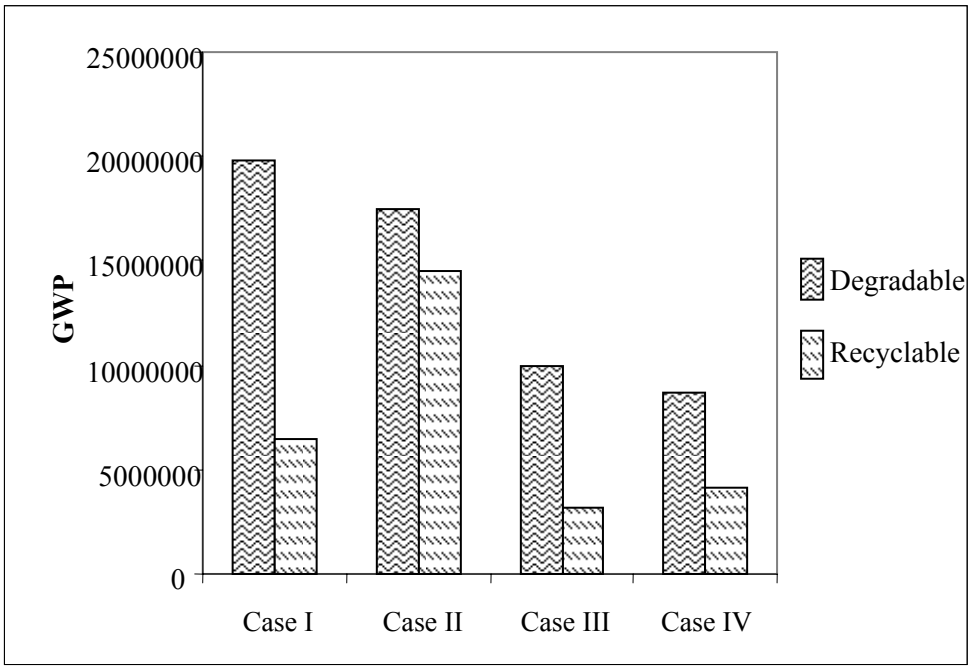

Figure 14. GWP for recommended options of design of TS

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