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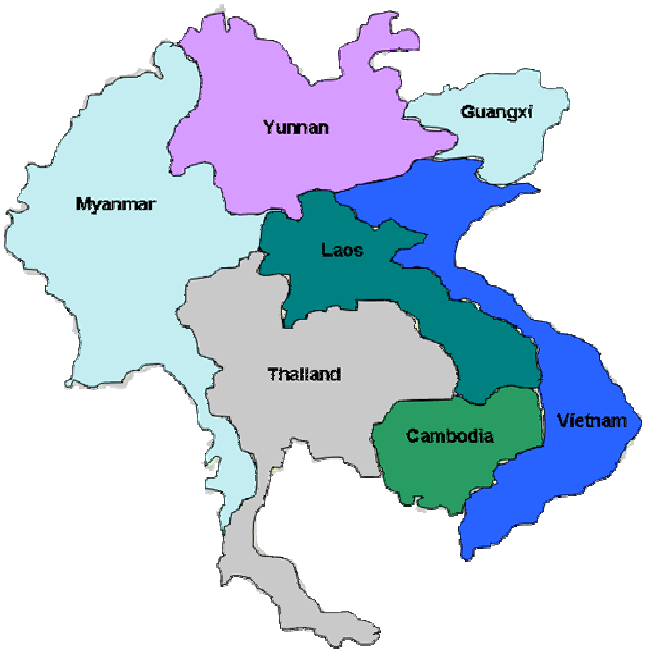

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CONTENTS

Assessing Biophysical and Socioeconomic Condition for Watershed Management: Case of Khlong Yai Watershed, Eastern Thailand

Rajendra P. Shrestha* and Nalina Gnanavelrajah

Abstract— *A study was carried out at Khlong Yai watershed of Thailand to assess soil erosion, and land suitability evaluation to examine the general land degradation status in terms of appropriateness of present land uses, and explore factors influencing farmers' choices on land use selection. The study used both biophysical and socioeconomic data with standard available methodologies of soil erosion assessment and land evaluation. The data were collected from several sources including household survey. The study indicates that there is however enormous changes in land uses mostly due to commercial orientation the area has no serious soil erosion problem in general. The general choice of land use in the area is for tree crops due to commodity price for higher income, and other factors, such as traditional practice and tenure arrangement, nevertheless it is worth considering appropriate management practices in the area with tree crops as such cultivation practices diminishes ecological potential of land by diminishing soil fertility and biological diversity as well.*

***Keywords*— Soil erosion, land suitability, socio-economic, Thailand.**

1. INTRODUCTION

Land resources have been adversely impacted by several factors, such as the rapid urban and industrial growth, extensive deforestation and unsustainable agriculture, including in adequate soil conservation, cultivation of steep slopes and overgrazing [1]. Inappropriate agricultural activities is one of those factors causing impacts, such as land degradation, loss of biodiversity, and even increased Carbon dioxide (CO_2) emissions. Soil erosion is one of the pervasive land degradation problems in several Asian developing countries, including Thailand. Soil erosion causes losses in soil productivity, degradation of landscape, degradation of water quality, and loss of organic carbon [5] [6]. Thailand is estimated to have its one third of land area affected by severe degradation and soil erosion due to water being the major type [2] excluding other forms of problem soils which pose serious limitation to agricultural production. Rate of soil erosion in Thailand ranges from 15 to 200 tons/ha/yr have [3]. Twelve percent of the total eroded lands of the country are primarily under field crops and shifting cultivation, which have very severe hazard severity [4].

Taking decision to put a given land unit into a specific use depends on both internal and external factors. Amongst, the biophysical factor, e.g. land quality, although is the major factor in determining land uses due to its influence on potential production, most often decisions are driven by economic and political factors [7] often leading to misuse of land or inappropriate management practices. While soil erosion assessment, and land suitability evaluation, which assesses the performance of land for specified uses, are important in the watershed context to determine the productive potential of any given land unit in the watershed, consideration of socioeconomic and political factors are equally vital for holistic planning and management of the watershed resources to achieve sustained production and ecosystem services. On this premises, this study had the following objectives:

1. Assess land degradation in terms of soil erosion severity
2. Analyze land suitability for major crops, and
3. Study the socioeconomic condition in the study area in terms of peoples' perception to examine the constraints and awareness towards conservation.

2. STUDY AREA

The study area, Khlong Yai watershed of Thailand is situated in the eastern central part of Thailand covering 170,175 ha (Figure 1). The climate is tropical monsoon with 1383mm annual rainfall and 28.3 °C annual average temperature. Three-fourth of the watershed has flat to gently undulating topography with dominant soil types of fine loamy, clayey making it suitable for cultivation. In the recent decades, the area has experienced large scale land use change and modification mostly of commercial orientation.

Agricultural land-uses cover 80% of the study area, mostly upland crops (76%) and the rest as paddy cultivation area (4%). The study site has different types of shrub mono-cropping, shrub tree intercropping, tree mono-cropping and mix-cropping implying different types of land management practices and associated soil erosion severity. Among the agricultural land-uses, pararubber, mixed orchards, pineapple and cassava are the dominant land-uses which have area coverage of

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19.42, 16.3 12.94 and 12.14, respectively. Coconut, coconut-cassava intercropping, sugarcane, sugarcane-cassava rotation, pineapple-cassava rotation, eucalyptus and paddy were the other agricultural land-uses in the study area.

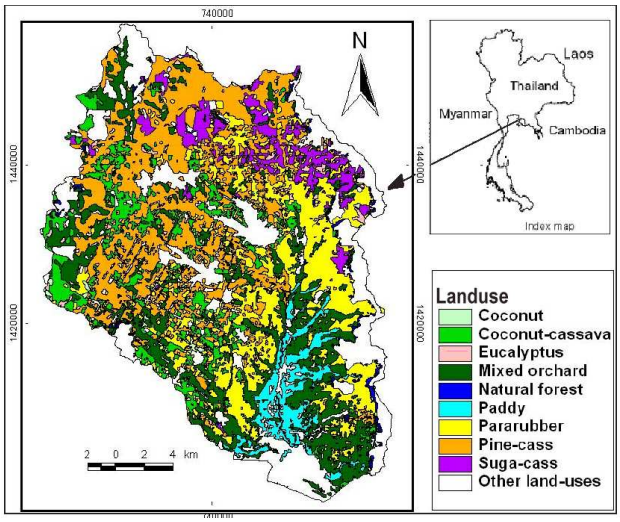

Fig.1. Location of the Study Area.

3. RESEARCH METHODOLOGY

The study aimed to asses i) the soil erosion severity in the study area, ii) land suitability, and iii) explore farmers' perception towards soil conservation. Hence, both primary and secondary data of biophysical, social and economic characteristics were collected and used in the study. Table 1 presents the secondary data used in the study were:

Table 1. Data types and sources

Data	Sources	Data type
Land-use	Department of Land Development	Land-use map 2000 Scale 1: 100 000
Soil	Department of Land Development	Soil map 2003 Scale 1:100 000
Topography	Department of Land Development	Topographic map Scale 1: 50 000
Climate	Meteorological stations in study area	Monthly Rainfall, Temperature, and evaporation 1994 - 2004

Soil erosion reduces the soil's depth and thus the capacity of land to hold water and the amount of nutrients it contains. Land-use and management practices of watershed should be aimed to keep the soil loss due to erosion below acceptable limits. In this regard the present level of soil erosion in the watershed was assessed using the Universal Soil Loss Equation (USLE) given by Wischmeir and Smith [8], which has been successfully used in several studies. The equation can be written as

E = RKLSCP

Where, E= annual soil loss (tons/ha/yr)

R = rainfall erosivity

K = soil erodibility

L = slope length

S = slope steepness

C = crop management, and

P = erosion control practice

These factors were modified in Thailand context as per available information (refer to [9] for detail methodology). R factor was computed using annual rainfall data, K from soil data, L and S combinely estimated based topography, C and P from landuse data.

Land suitability analysis when used for specified purposes, provides a rational basis for sustainable land-use and management. Each land unit has its own potentialities and limitations. On the other hand, each land-use has its own biophysical requirements. Almost all crops could be cultivated in any piece of land with external inputs. However, external inputs or improvements are expressed in terms of capital, energy, or environmental costs. The main aim of land suitability analysis is to minimize these socio-economic and environmental costs by predicting the inherent capacity of a land unit to support a specific land-use and management for a long period of time without deterioration. Biophysical suitability of the agricultural land-uses was evaluated by carrying out a land suitability classification according to Framework of land evaluation [10]. The land-use requirements were used as suggested by Land Development Department of Thailand [11] to classify four suitability classes: highly suitable (S_1), moderately suitable (S_2), marginally suitable (S_3) and non suitable (N). A total of fourteen diagnostic factors namely annual rainfall or water requirement during growing period, mean annual temperature, organic matter content, available phosphorus and potassium, soil depth, pH, cation exchange capacity, base saturation, electrical conductivity, drainage, frequency of flooding, slope gradient and stoniness were considered in this study. These factors were encoded in rainfall map and soil map.

Scores were given for each level of suitability. The weight for each diagnostic factor was assigned according to the importance of each diagnostic factor for each crop and the ease with which the factor could be managed. The factors which can not be easily managed were given more weightage compared to the factors which could be easily altered. Index overlay modeling technique was used to combine the data and perform overlay analysis [12].

$$S = \sum_i^n SiWi \quad (1)$$

where, S = Weight score for mapping unit; S_i = Score

for i^{th} diagnostic factor; W_i = Weight of i^{th} diagnostic factor

Final rating of suitability of each mapping unit was assigned as highly suitable, moderately suitable, marginally suitable and not suitable depending on the score.

Both soil erosion and land suitability assessments were carried out using vector-based Geographic Information Systems (GIS).

Field works for ground truthing and household level socioeconomic data collection were conducted. A household survey was conducted to gather information on socioeconomic status and peoples' perception toward resource degradation and conservation. Altogether 75 representative households having major land use types found in the area were interviewed by administering structured questionnaire in the early 2006.

4. RESULTS AND DISCUSSION

4.1 Soil Erosion Assessment

The computed potential soil erosion presented according to different land-use types in Table 2 indicates that 84% of the agricultural land-uses have potential erosion rate less than 2 tons/ha/yr.

Table 2. Potential erosion rate in Agricultural landuses

	Rate of erosion (tons/ha/yr)				
	2	2-4	4-12	>12	Total area
Land-use	% Area under different erosion rate				(%)
Cassava	62	13	18	7	10.46
Coconut	57	13	26	3	0.45
Coconut-cassava	60	16	22	1	0.36
Eucalyptus	70	5	17	8	1.22
Mixed orchard	87	8	4	1	15.99
Paddy	100				4.91
Para rubber	85	8	4	3	18.84
Pineapple-cassava	78	7	14	1	5.55
Pineapple	100				13.71
Sugarcane-cassava	76	4	15	5	8.67
Sugarcane					0.61
Other land-uses					19.2
Average/Total	84	6	7	3	100

Total area – 170174 ha

Six and seven percent of area have 2-4 and 4-12 tons/har/yr soil erosion, respectively. Only 3% of agricultural land-uses have potential erosion rate higher than maximum permissible limit of erosion rate (PSL) of 12 tons/ha/yr. This is due to the fact that more than three-fourth of the area has flat to gently undulating topography which is less subject to high erosion compared to the high slope areas. Figure 2 presents the distribution of areas under different rate of above PSL.

Among the land use types with relatively higher soil erosion rates were Eucalyptus, Cassava, Sugarcane-Cassava mixed crop, and Para rubber.

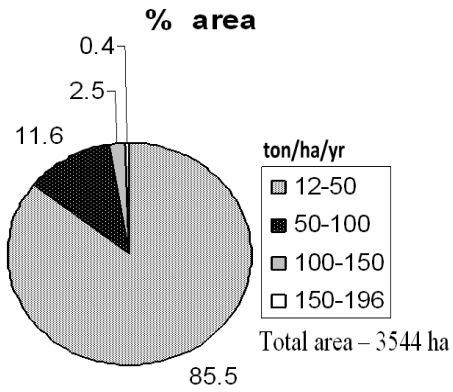

Fig. 2. Distribution of areas under different rate of erosion above permissible limit.

4.2 Land Suitability Analysis

The results of land suitability analysis of major crops of study area indicate that pineapple, cassava, coconut and orchard are the more suitable crops in terms of area of suitability according to biophysical suitability. In this regard 52.81 and 27.69% of total area is highly and moderately suitable for pineapple cultivation. The similar figures for cassava, pararubber, coconut and orchard are 45.12 and 35.38, 43.61and 37.02, 43.49 and 45.89 and 23.02 and 53.19 respectively. On the other hand sugarcane and paddy have less suitable areas compared to the above crops.

Table 3. Land suitability of present landuses.

	Area under different suitability (%)				Total area
	Highly	Moderately	Marginally	unsuitable	
Land-use	suitable	suitable	suitable		(ha)
Cassava	75	24	0	1	17858
Coconut	44	55	1	0	769
Coconut – cassava	-	100	-	-	612
Eucalyptus	100	-	-	-	2070
Mixed orchard	21	54	20	5	27205
Paddy	35	51	12	2	8351
Para rubber	45	54	0	1	32067
Pineapple-cassava	52	45	0	3	9445
Pineapple	81	16	0	3	23335
Sugarcane-cassava	9	87	4	0	14761
Sugarcane	16	76	5	8	1031
Sub total	47	46	5	2	137504
Other land-uses*					32671

* no suitability assessed

Comparison of present land use in terms of respective biophysical suitability, it was found that 47% of the present land-uses are highly suitable, 46% under moderately suitable, 5% under marginally suitable and 2% are non-suitable (Table 3). Spatial distribution of different suitable category of present land uses is shown in Figure 3. Pineapple, cassava, coconut and orchard are the relatively more suitable crops in terms of present area coverage, for example 81% and 75 % of pineapple and cassava land-uses are being cultivated in highly suitable areas, respectively. Sugarcane and paddy have relatively

less suitable areas. Only 45% or the para rubber land-uses are cultivated in highly suitable area.

4.3 Assessment of socioeconomic condition and farmers' perception

Socioeconomic Profile

The age of respondents ranged from 35 and 80 and minority (4%) percent were illiterate. 64 percent were engaged only in agriculture while 36 percent had also second occupation to agriculture. Average household size was of 4 members in the family. 49% had only owned lands, 15% had only rented-in land while 36% had both owned and rented-in lands. In general, majority farmers with tree crops, namely coconut, coconut, eucalyptus, mixed orchard, and pararubber, were observed to have owned their land. The average holding of owned land was 9.13 ha while rented-in holdings average 21.4 ha.

Number of crops grown by the farmer and cropping pattern adopted affect the household income, resilience, and sustainability of land-use. 39% respondents grow only one crop while 29, 8 and 9% grow two, three and four crops, respectively in a year. Varieties of cropping practices (monocropping, rotations, intercropping) are found for different land uses.

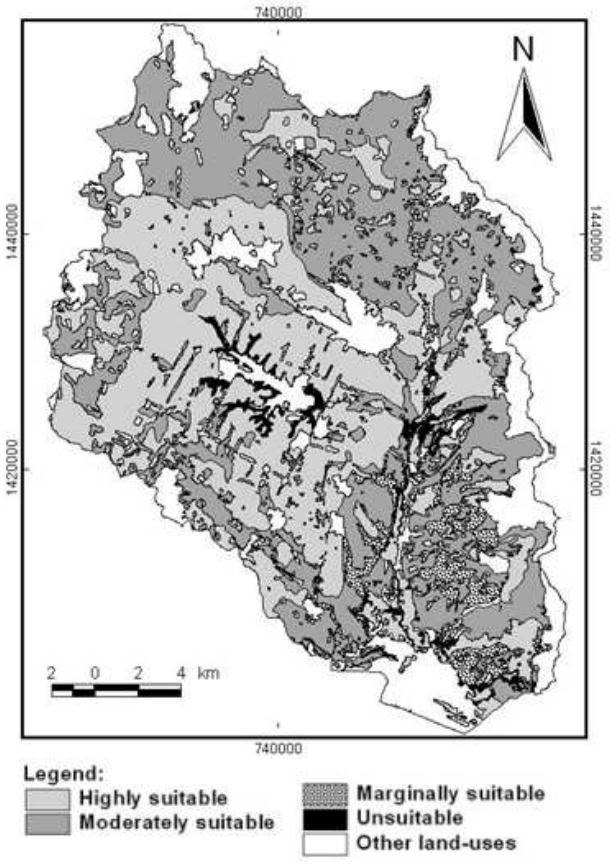

Fig.3. Suitability of present land-uses in the study area

49% of surveyed households had only owned lands, 15% had only rented in land while 36% had both owned and rented in lands. In general, most farm households growing tree corps (coconut, eucalyptus, mixed orchard, para rubber) have their own land compared to those who are growing shrub crops (sugarcane, cassava). The average size of owned land in the study area was 9.13 ha, where as 21.4 ha in case of rented in land. More than four fifth (83%) of respondents having own land had title deed, which provides full ownership of land. Percentages of respondents having other category of land documents which do not provide full ownership like title deeds do, such as *Nor Sor 3, Sor Tor Kor, Sor Por Kor*, were 1.59, 3.17 and 12.69, respectively. Among the farmers having own land, all who cultivates eucalyptus, mixed orchard, paddy, pineapple and sugarcane-cassava and 75% of land-users of coconut, coconut-cassava, para rubber, and sugarcane had title deed.

Landuse Choices and Conservation Practices

According to the survey 40% of the farmers take decision about their land-use based on commodity price while 32% are following land-uses as traditional practice (Table 4). Another 12% of land-users select land-use based on the criteria of the ease of cultivation or one time investment needed for long period of benefits. Other 4% and 1% decide on type of land-use, based on basic needs and guide from officers respectively.

Pineapple, pineapple-cassava and sugarcane-cassava growers made their land-use decisions either by commodity prize or due to traditional practice. All farmers cultivating sugarcane responded that they were growing sugarcane as a traditional practice.

Table 4. Basis of land use choices

Land-use wise respondents	Basis of decision Making (% HH)					
	Commodity price	Traditional practice	Land quality	Basic needs	Guide from Officers	Ease of Cultivation
Cassava	33	45	11			11
Coconut		75		25		
Coconut-cassava	50	25	25			
Eucalyptus	75					25
Mixed orchard	33	25	17	8	8	8
Paddy		25	50	25		
Para rubber	42		8			50
Pineapple	70	30				
Sugarcane		100				
Pineapple-cassava	60	40				
Sugarcane-cassava	57	43				
Total	40	34	9	4	1	12

Meeting the basic needs as a factor of land-use decision was reported by few farmers growing coconut, mixed orchard and paddy. Other farmers cultivating cassava (11%), eucalyptus (25%), mixed orchard (8%) and para rubber (50%) responded that they decided to cultivate such crops because of ease of cultivation or need of only one time big investment. Land quality was used as a criterion in land-use decision by few farmers growing cassava (11%), coconut-cassava (25%), mixed orchard (16%), paddy (50%) and para rubber (8%). Only 8% of mixed orchard farmers or 1% of total respondents makes land-use decisions based on guidance from officers in the study area. On an average, 80% households did not wanted to change their land-use in

near future except the households currently growing sugarcane of which majority (75%) wanted to change to orchard.

With regard to the farm households practicing soil and water conservation practices, more than half (56%) of the respondents were found adopting conservation practices. Among those adopting conservation measures a substantial majority (83%), use only organic manure while, 12% use both organic manure and mulching and 5% use organic manure and bio-fertilizers. Farmers growing eucalyptus or paddy did not practice any conservation practice. On the other hand all the farmers growing pineapple or sugarcane-cassava adopt conservation measures. Some farmers from land-uses orchard, coconut, pineapple-cassava and coconut-cassava use organic manure as the conservation measure. Organic manure and bio-fertilizer was used by sugarcane or sugarcane-cassava land-users.

Economics of Production

Economic analysis was done to compare the economic return from different land-uses. The land-uses in the study area differ in terms of time span between investment and return, as there are short term crops and different perennial crops. Hence, benefit-cost ratio was calculated based on net present value up 28 years. The time period of 28 years was selected because of the lifespan of most perennial crop land-uses in the study area last up to 30 years and land-use such as eucalyptus which has up to 7 years for one cropping would complete 4 cycles during 28 years. The results indicate that land-use sugarcane had the least benefit cost ratio of 2.08, while land-use coconut had the highest of 5.38. Next to coconut, eucalyptus has higher B/C ratio of 5.32. Mixed orchard and coconut-cassava has 3.55 and 3.49 respectively. Comparatively higher B/C ratio for coconut and eucalyptus is mainly attributed to the very low cost of production of these crops, due to less intense weed and fertilizer management. Pineapple-cassava, pineapple, sugarcane-cassava, para rubber, cassava, and paddy has B/C ratio 3.2, 3.06, 2.73, 2.5, 2.45 and 2.39 respectively (Table 5).

Table 5. Benefit cost ratio of land-uses

Land-use	Benefit-cost ratio
Cassava	2.45
Coconut	5.38
Coconut-cassava	3.49
Eucalyptus	5.32
Mixed orchard	3.55
Sugarcane	2.08
Sugarcane-cassava	2.73
Para rubber	2.5
Pineapple	3.06
Pineapple-cassava	3.2
Paddy	2.39

Perception on Environment

Perception of farm household regarding some aspect of environment, such as importance of organic matter, soil fertility status, and soil erosion, was investigated using questionnaire survey as it helps to understand their level of awareness and attitude towards environmental conservation.

Regarding importance of organic matter (OM) and its application in the agricultural field, almost all farmers (97%) are aware that organic matter improves land quality. However, majority 52% were not actually applying OM for various reasons, such as high cost, no OM production in farm household, and old age of plantations. In relation to soil fertility status, most farm households (63%) in the study area thought that the soil fertility in their agricultural field had been decreased in last ten years or so and the rest thought no change or were not about the either kind of change. Interestingly, most of them who thought the soil fertility has decreased were the household growing upland crops not paddy.

About 47% farm household thought that soil erosion in their farm land has increased in the recent past and again these were the farm households mostly growing the upland crops. This is interesting to note that computed soil erosion assessment as discussed before however did not show significant erosion with respect to permissible soil loss, farm households are concerned about the soil loss implying greater awareness about the need of soil conservation. In relation to farming practices, there were mixed responses about the mono-cropping and productivity depending upon the type of crops they have been growing although mono-cropping in general is regarded to decrease soil fertility and less stable farming system.

5. CONCLUSION AND RECOMMENDATIONS

The study generates some important information that could be used to guide watershed management activities in the area. The study revealed that the area has no serious soil erosion problem as small percentage of area exceeds permissible soil loss. Nevertheless, substantial proportion of household perceiving increased soil erosion in the recent past calls for cautions to practice improved management practices and not erode soils.

Of the evaluated landuses, the land suitability analysis of present land-uses shows that 47% of the present land-uses are highly suitable, 46% under moderately suitable, 5% under marginally suitable and 2% are non-suitable. This implies there is scope and need to appropriate match the land uses according to the land quality for enhancing the production while conserving the health of soil for sustained production. As indicated, commodity price is one of the major factors influencing land use decision-making and the tree-crops have usually higher benefit compared to the annual crops, and majority of farmers would like to have such crops but are constrained because of the land tenure arrangements. Tree-crops seem to be the first choice because of the fact that there is market available and relatively stable price. Choice of tree crops might also help claim long term ownership on the given piece land.

It is however important to give due consideration for better management practices in these lands. It is

particularly important in case of shrub crops with mono-cropping, such as cassava, pineapple and sugarcane as they tend to have relatively higher erosion and less plant diversity undermining ecological stability of land unit. Farmers are well aware of the beneficial effects of organic manures and trees on soil fertility but are not adequately able to practice because of unavailability or high cost and this calls for necessary support to enable to them to use organic matter for maintaining soil quality and eventually sustain production.

Although not within the scope of this paper to discuss, it is most often the national policy for economic gain which has been influencing the land use particularly the conversion to monocropping of economic commercial crops , such as cassava, pararubber. Land degradation and land suitability assessment to assist in making right kind of land use decision making are prerequisites from the perspective of food security, ecosystem sustenance and also the mitigation and adaptation of climate change, a global concern.

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Adsorption of Cd(II) and Pb(II) onto Clarified Sludge - Kinetics, Thermodynamics and Desorption and Application Study

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Abstract— *Clarified sludge is a major waste obtained from basic oxygen furnace during steel making process. In the present study clarified sludge has been characterized and used for the removal of Cd(II) and Pb(II) from aqueous solution. The effect of various physicochemical parameters such as pH, adsorbent dosage, adsorbate concentration, contact time and temperature on adsorption process was studied in batch experiments. Kinetics data for the adsorption of Cd(II) as well as Pb(II) were best described by pseudo-second order model. The effective diffusion co-efficient of for Cd(II) and Pb(II) adsorption were of the order of 10^{-11} m^2/s and 10^{-10} m^2/s respectively. The maximum uptake were 36.23 mg/g and 92.51 mg/g for adsorption of Cd(II) and Pb(II) respectively. The adsorption data for both the metal adsorption can be well described by Langmuir and Freundlich isotherm respectively. The result of the equilibrium studies showed that the solution pH was the key factor affecting the adsorption. The optimum pH for both the adsorption was 5. Mass transfer analysis was also carried out for the adsorption process. The values of mass transfer coefficients (β) obtained from the study indicate that the velocity of the adsorbate transport from bulk to the solid phase was quite fast. The thermodynamic studies indicated that the adsorption is spontaneous and exothermic for Cd(II) adsorption and endothermic for Pb(II) adsorption. The sorption energy calculated from Dubinin-Radushkevich isotherm model indicated that both the metal adsorption process were chemical in nature. Desorption studies were carried out using dilute mineral acids to elucidate the mechanism of adsorption. Application studies were carried out considering the economic viewpoint of wastewater treatment plant operations.*

Keywords— Clarified sludge, Adsorption, Pseudo second order, Freundlich adsorption isotherm, Mass transfer.

1. INTRODUCTION

Rapid industrialization has lead to increased disposal of heavy metals into the environment. Environmentalists are primarily concerned with the presence of heavy metals due to their toxicity and impact on human health and environment. The harmful effects of Cd(II) include acute and chronic metabolic disorders, such as itai-itai disease, renal damage, emphysema, hypertension and testicular atrophy etc. [1-2]. Lead poisoning in human causes severe damage to kidney, nervous system, reproductive system, liver and brain. Severe exposure to lead has been associated with sterility, abortion, stillbirths and neo-natal deaths etc. [3-4].

Cadmium is introduced into the water from smelting, metal plating, cadmium-nickel batteries, phosphate fertilizers, mining, pigments, pigments, stabilizers, alloy industries and sewage sludge. Where as Process industries, like battery manufacturing, printing and pigment, metal plating and finishing, ammunition, soldering material, ceramic and glass industries, iron and steel manufacturing units generate large quantities of lead.

Due to toxicity, the recommended maximum tolerance intake of Cd(II) by IS 10500 for discharge in inland surface water and public sewers are 2.0 and 1.0 mg/L respectively [5]. The permissible level of Pb(II) in water according to World Health Organization is 0.05 mg/L [6] and in wastewater as set by Environment Protection Agency [7] is 0.05 mg/L. Where as the tolerance limit of Pb(II) according to Bureau of Indian Standards (BIS) is 0.1 mg/L [8].

The safe and effective disposal of metal containing wastewater is a challenging objective for industries because cost-effective treatments alternatives are not readily available. Conventional technologies for the removal of heavy metal are chemical precipitation, ion exchange, electrochemical precipitation, solvent extraction, membrane separation, concentration, evaporation, reverse osmosis, emulsion per traction and adsorption. Among these technologies, adsorption is a cost-effective and user friendly technique which can be used only at the tertiary stage for the removal of heavy metal [9].

2. MATERIALS AND METHODS

The clarified sludge was collected from the sludge thickener of Basic Oxygen Furnace of Rourkela Steel Plant, Rourkela, Orissa, India. The sludge initially in the dust form in the basic oxygen furnace was arrested by hydro jetting followed by passing through venture scrubbers and then collected from clarifier after settling.

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Clarified sludge, after collection it was ground, homogenized and dried at 105 ± 5 ^{0}C for 3 hr and cooled to ambient temperature in a desiccators.

All the necessary chemicals used in the study were of analytical grade. Cadmium nitrate tetra hydrate [$Cd(NO_3)_2$, $4H_2O$] and Lead nitrate [$Pb(NO_3)_2$] were obtained from E. Merck Limited, Mumbai, India. Stock solution of the above heavy metals was made by dissolving exact amount of respective metal salt.

Different initial concentration of metal solutions was prepared by proper dilution from stock 1000-ppm metal standard. pH of the solution was monitored in a 5500 EUTECH pH Meter using FET solid electrode calibrated with standard buffer solutions. Necessary amount of clarified sludge was then added and contents in the flask were shaken for the desired contact time in an electrically thermo stated reciprocating shaker @ 120-130 strokes/min at 30^{0}C. The remaining metal concentration in the sample was analyzed using Atomic Absorption Spectrophotometer (VARIAN SPETRA AA 55, USA) as per procedure laid down in APHA, AWWA standard methods for examination of water and wastewater, 1998 edition [10].

3. RESULTS AND DISCUSSION

3.1 Effect of pH, contact time, adsorbent dosage

In order to evaluate the influence pH on the adsorption, the experiments were carried out at different initial pH values. The pH range was chosen as 2-7 in order to avoid metal hydroxides. The effect of pH on adsorption efficiencies are shown in Figure 1. The uptake of Cd(II) by clarified sludge increased as the pH increased. Although a maximum uptake was noted at a pH of 8, as the pH of the solution increased to >7, Cd(II) started to precipitate out from the solution. Therefore experiments were not conducted over pH 7. The increased capacity of adsorption at pH >7 may be a combination of both adsorption and precipitation on the surface of the adsorbent. It is considered that clarified sludge had a maximum adsorption capacity at a pH = 5, if the precipitated amount is not considered in the calculation. The pH range was chosen as 3-7 in order to avoid precipitate in the form of lead chloride and lead hydroxides, which has been estimated to occur at pH<2.0 for $PbCl_2$ and pH>6.5 for $Pb(OH)_2$. The effect of pH on adsorption efficiencies are shown in Figure 1. Removal of Pb(II) increases with increasing solution pH and a maximum value was reached at an equilibrium pH of around 5.

The metal ions in the aqueous solution may undergo solvation and hydrolysis. The process involved for metal adsorption is as follows [11],

$$M^{2+} + nH_2O = M(H_2O)_n^{2+} \quad (1)$$

$$M(H_2O)_n^{2+} = [M(H_2O)_{n-1}(OH)]^+ + H^+ \quad (2)$$

$$M^{2+} + nH_2O \overset{K_a}{=} [M(H_2O)_{n-1}(OH)]^+ + H^+ \quad (3)$$

The pK_a value for Cd(II) and Pb(II) are 10.1 and 7.7 respectively. Perusal of the literature on metal speciation shows that the dominant species is $M(OH)_2$ at pH > 6.0 and M^{2+} and $M(OH)^+$ at pH < 6.0. Maximum removal of metal was observed at pH 5 for adsorption. On further increase of pH adsorption decreases probably due to the formation of hydroxide of cadmium and lead because of chemical precipitation. The optimum pH value for adsorption was found to be 5.

The effect of shaking time on the adsorption of Cd(II) and Pb(II) ion are shown in Figure 2. During the experiment contact time was varied from 0 to 5 h for adsorption of Cd(II) and 0 to 3 h for adsorption of Pb(II). The effect of contact time variation in the Figure 2 indicates that the adsorption processes reach the equilibrium after 2 h and 1 h respectively for adsorption of Cd(II) and Pb(II). The initial rapid adsorption gives away a very slow approach to equilibrium.

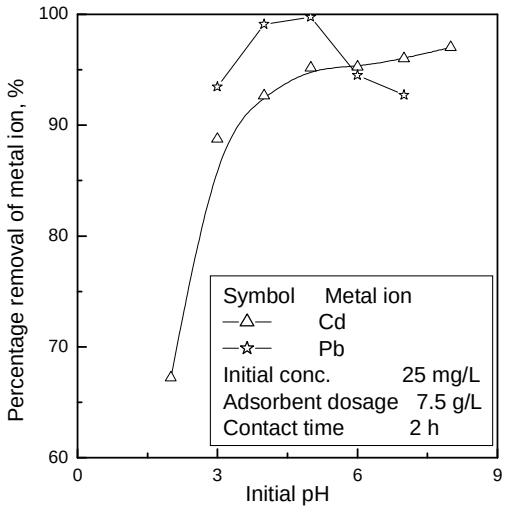

Fig. 1. Effect of pH on Cd(II) and Pb(II) removal.

Effect of adsorbent dosage on the removal of Cd(II) and Pb(II) was studied using Clarified sludge at concentration ranging from 1g/L to 30g/L. With an increase in adsorbent dosage, the metal ion removal increased to higher metal ion uptake by the increased amount of adsorbent. For higher adsorbent dosage, the incremental metal ion removal becomes very low as the surface metal ion concentration and the solution metal ion concentration comes to equilibrium with each other. The optimum adsorbent dosage on the Cd(II) and Pb(II) removal were found to be 7.5 g/L for both the cases.

3.2 Adsorption kinetics model

The study of adsorption kinetics describes the solute removal rate and evidently this rate controls the residence time of adsorbate removal at the solid - solution interface including the diffusion process. The mechanism of adsorption depends on the physical and chemical characteristics of the adsorbent as well as on the mass transfer process. With the maximum shaking speed of 120 rpm, it was assumed to offer no mass transfer (both external and internal external) resistance to the overall adsorption process. Therefore kinetic can be studied through the residual metal ion concentration in the solution. The rate kinetics of metal ion adsorption on clarified sludge was analyzed using pseudo first-order

[12], pseudo-second order [13], and intraparticle diffusion models [14]. The conformity between experimental data and the model predicted values was expressed by correlation coefficients, r^2 and Chi-square test, χ^2.

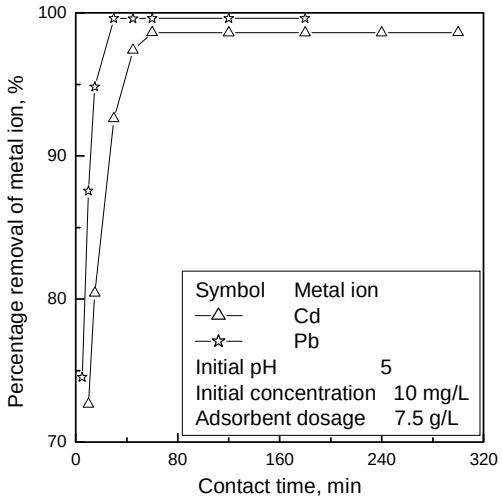

Fig. 2. Effect of contact time on Cd(II) and Pb(II) removal.

3.2.1 Pseudo first order model

The pseudo first order kinetic model was proposed by Lagergren [12]. The integral form of the model generally expressed as follows:

$$\log(q_e - q) = \log q_e - \frac{K_{ad} t}{2.303} \quad (4)$$

3.2.2 Pseudo second order model

The kinetics of adsorption process may also be described pseudo second order rate equation [13]. The lineralized form of equation is expressed as

$$\frac{t}{q} = \frac{1}{K_2 q_e^2} + \frac{1}{q_e} t \quad (5)$$

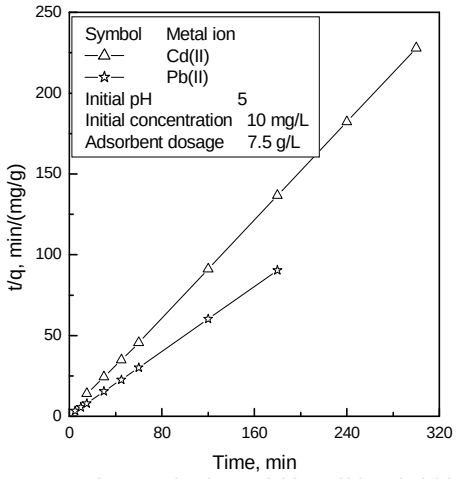

Fig. 3. Pseudo second order model for Cd(II) and Pb(II) removal.

3.2.3 Intraparticle diffusion model

The adsorbate transport from the solution phase to the surface of the adsorbent particles occurs in several steps. The overall adsorption process may be controlled either by one or more steps, e.g. film or external diffusion, pore diffusion, surface diffusion and the adsorption on the pore surface, or a combination of more than one steps. Generally, a process is diffusion controlled if its rate dependent upon the rate at which components diffuse towards one another. The intraparticle diffusion model is based on the theory proposed by Weber and Moris [14]. According to this theory

$$q = K_{id} t^{0.5} \quad (6)$$

The values of rate constants and correlation coefficients for each model are shown in Table 1. In addition, the Chi-square test was also done to support the best fit adsorption model. The equation for evaluating the best fit model is to be written as

$$\chi^2 = \sum \frac{(q_t - q_{tm})^2}{q_{tm}} \quad (7)$$

It has been found that χ^2 values are much less in pseudo second order model (Figure 3) than that of pseudo first order and intraparticle diffusion model (Table1). Thus based on the high correlation coefficient and low χ_t^2 value, it can be said that adsorption of Cd(II) and Pb(II) onto clarified sludge follow pseudo second order model.

3.2.4 Mass transfer analysis

Mass transfer analysis for the removal of Cd(II) and Pb(II) from aqueous solutions by clarified sludge were carried out using the following equation as proposed by McKay et al.[15].

$$\ln\left(\frac{C_t}{C_o} - \frac{1}{1+MK_{bq}}\right) = \ln\left(\frac{MK_{bq}}{1+MK_{bq}}\right) - \left(\frac{1+MK_{bq}}{MK_{bq}}\right)\beta_s t \quad (8)$$

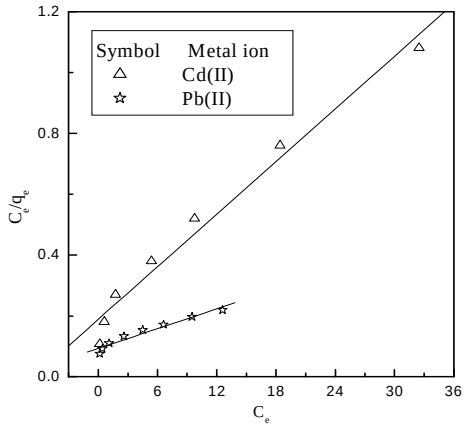

Fig. 4. Langumir plot for adsorption of Cd(II) and Pb(II) removal.

Table 1. Rate Kinetics for adsorption of Cd(II) and Pb(II) by clarified sludge

Metal	Lagergren 1st Order			Pseudo 2nd Order			Weber and Moris		
	$K_{ad}x10^{-2}$ min^{-1}	r^2	χ^2	K_2 $g.mg^{-1}.min^{-1}$	r^2	χ^2	$K_{id}\,x10^{-2}$ $mg.g^{-1}.min^{-1/2}$	r^2	χ^2
Cd(II)	7.37	0.998	2.045	1.606	0.999	0.026	6.40	0.931	1.179
Pb(II)	16.47	0.958	8.389	0.467	0.999	0.019	14.89	0.869	0.847

Table 2. Langmuir and Freundlich adsorption isotherm constants for Cd(II) and Pb(II) removal

Metal	Langmuir Constants				Freundlich Constants			
	q_{max} (mg g^{-1})	B (L mg^{-1})	r^2	χ^2	K_f	n	r^2	χ^2
Cd(II)	36.23	0.14	0.992	1.184	4.37	1.77	0.994	1.475
Pb(II)	92.51	0.115	0.953	0.676	8.872	1.304	0.998	0.539

Table 3. Thermodynamic parameters for the adsorption of Cd(II) and Pb(II) on clarified sludge

Metal	T (K)	$-\Delta G^0$ (kJ/mol)	ΔH^0 (kJ/mol)	ΔS^0 (kJ/mol)	r^2
Cd(II)	303	10.621	-25.741	-0.050	0.928
	313	9.693			
	323	9.632			
Pb(II)	303	11.092	28.384	0.130	0.999
	313	12.369			
	323	13.698			

The values of mass transfer coefficients (β) were $2.514x10^{-5}$ cm s^{-1} and $4.873x10^{-5}$ cm s^{-1} with a high value of co-relation co-efficient for the removal of Cd(II) and Pb(II) respectively. Mass transfer coefficients (β) obtained from the study indicate that the velocity of the adsorbate transport from bulk to the solid phase was quite fast.

3.2.5 Determinatin of diffusivity

Kinetic data could be treated by the models given by Boyd et al.[16] which is valid for the experimental conditions used. Diffusion found to be rate controlling in the adsorption of Cd(II) and Pb(II) onto the particles of spherical shape. For the range $0 \leq F(t) \leq 1$ in the solution of divalent exchangeable ions, Boyd equation can be simplified as [17-19]

$$\ln\left[\frac{1}{1-F^2(t)}\right] = \frac{\pi^2}{R_a^2} D_e t \qquad (9)$$

The value of diffusion co-efficients as calculated from the equation (9) were found to be 2.3×10^{-11} and 1.7×10^{-10} m^2/s for the adsorption of Cd(II) and Pb(II) onto clarified sludge respectively. For the present system, the value of D_e, fall within the values reported in literature, especially for chemisorptions system (10^{-9} to 10^{-17} m^2/s) [20].

3.3 Adsorption isotherms model

The adsorption isotherm for the removal of metal ion was studied using initial concentration of between 10 and 300 mg/L at an adsorbent dosage level of 7.5 g/L for Cd(II) and Pb(II) at 30°C.

3.3.1 Langmuir isotherm model

The Langmuir equation is based on the assumption of a structurally homogeneous adsorbent where all sorption sites are identical and energetically equivalent. The Langmuir adsorption isotherm [21] applied to equilibrium adsorption assuming mono-layer adsorption onto a surface with a finite number of identical sites and is represented as follows,

$$\frac{C_e}{q_e} = \frac{1}{q_{\max} b} + \frac{C_e}{q_{\max}} \qquad (10)$$

Linear plots of C_e/q_e vs. C_e (Figure 4) were employed to determine the value of q_{max} (mg/g) and b (L/mg).

3.3.2 Freuindlich isotherm model

The Freundlich adsorption isotherm [22] is an empirical equation employed to describe heterogeneous systems, in which it is characterized by the heterogeneity factor, n. The linear form of Freundlich adsorption isotherm takes

the following form

$$\log q_e = \log K_f + \frac{1}{n}\log C_e \quad (11)$$

The Freundlich isotherm constants K_f and n were calculated from Equation (11) and Freundlich plots (Figure 5).

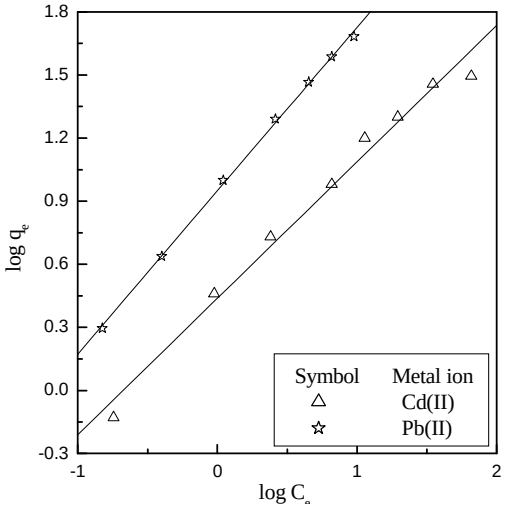

Fig. 5. Freundlich plot for Cd(II) and Pb(II) removal.

From the Table 2, it was seen that for Cd(II) adsorption, χ^2 value of Langmuir is lower than the Freundlich adsorption isotherm model. Therefore uptake of Cd(II) preferably follows the Langnuir adsorption model but it is reverse for the adsorption Pb(II) on clarified sludge.

3.3.3 Dubinin-Radushkevich (D-R) isotherm model

D-R isotherm relates the heterogeneity of energies close to the adsorbent surface. If a very small sub-region of the sorption surface is chosen and assumed to be approximately by the Langmuir isotherm, the quantity, $\sqrt{\lambda}$ can be related to the mean sorption energy, E, which is the free energy for the transfer of 1 mole of metal ions from the infinity to the surface of the adsorbent. The D-R isotherm [23] was employed in the following linear form:

$$\ln C_{abs} = \ln X_m - \lambda\varepsilon^2 \quad (12)$$

The Polanyi potential, ε, can be expressed as,

$$\varepsilon = RT\ln(1+\frac{1}{C_e}) \quad (13)$$

A plot of C_{abs} vs ε^2 is shown in Figure 6. Using the calculated value of λ, it is possible to evaluate the mean sorption energy, E, from

$$E = \frac{1}{\sqrt{-2\lambda}} \quad (14)$$

The estimated value of E were11.03 kJ/mol and 9.902 kJ/mol for Cd(II) and Pb(II) adsorption respectively which indicates the process are chemisorptions in nature.

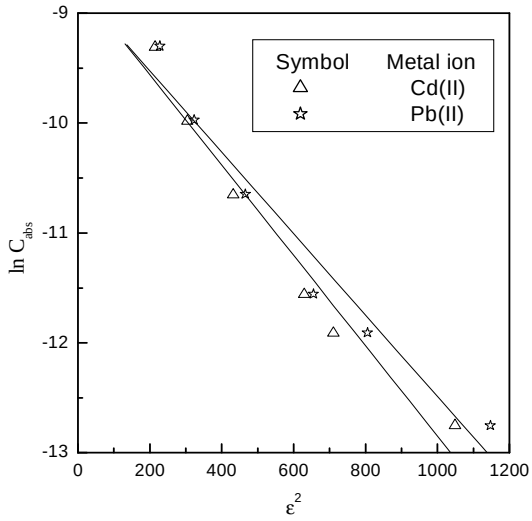

Fig. 6. D-R isotherm for Cd(II) and Pb(II) removal.

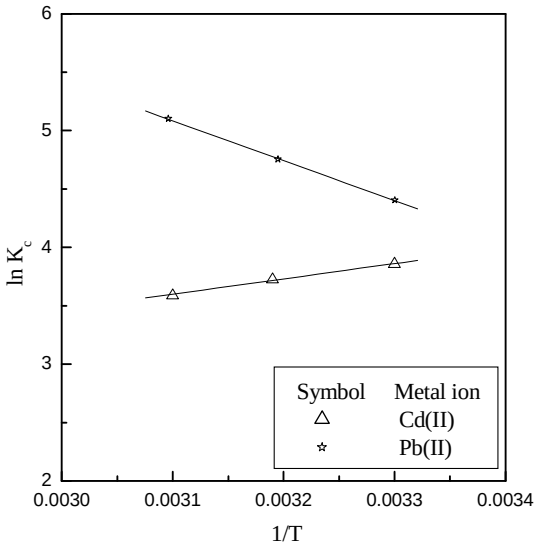

Fig. 7. Determination of thermodynamic parameter.

3.4 Thermodynamic study

The variation in the extent of adsorption with respect to temperature has been explained on the basis of thermodynamic parameters viz. changes in Gibbs free energy, enthalpy and entropy. The dependence on temperature of adsorption of Cd(II) and Pb(II) on the clarified sludge were evaluated using the following equations :

$$\ln K_C = -\frac{\Delta H^0}{RT} + \frac{\Delta S^0}{R} \quad (15)$$

$$\Delta G^0 = -RT\ln K_C \quad (16)$$

From the slope and intercept of the plot (Figure7), the values of ΔH^0 and ΔS^0 had been computed, while ΔG^0 were calculated using equation (16). The values of these parameters thus calculated are recorded in Table 3.

Table 4. Desorption of Cd(II) and Pb(II) from loaded Clarified sludge

Strength of HCl (M)	% Desorption of Cd(II)	Strength of HNO_3 (M)	% Desorption of Pb(II)
0.01	22.45	0.1	68.90
0.025	26.7	0.25	87.8
0.05	79.82	0.5	98.42
0.075	93.75	0.75	98.43
0.1	98.21	1	98.42
0.125	98.30		
0.15	98.28		

Table 5. Application studies using clarified sludge

Test Parameter	Untreated effluent	Treated Effluent	Untreated effluent	Treated Effluent	Remarks
PH	4.7	5	PH	2.7	--
Conductivity (μmhos/cm)	2760	2735	Conductivity (μmhos/cm)	1737	--
Cd(II) (mg/L)	3.8	0.076	Pb(II) (mg/L)	2.84	Successfully meet the IS 10500 1992 [6] norms of Cd(II) and Pb(II)
Fe (mg/L)	1.06	0.78	Fe (mg/L)	1.2	--
Ca (mg/L)	180	154	Ca (mg/L)	214	--
Mg (mg/L)	48	34	Mg (mg/L)	64	--
Chloride (mg/L)	28	24	Chloride (mg/L)	18	--
TSS (mg/L)	32	27	TSS (mg/L)	26	--

3.5 Desorption studies for Cd(II) and Pb(II) –clarified sludge system

Batch desorption experiments were carried out to further elucidate the mechanism of adsorption. Attempts were made to desorb Cd(II) and Pb(II) from clarified sludge using different concentration of HCl or HNO_3 solution having good potential to dissolve metal ions under study by batch desorption technique maintaining the same conditions similar to batch adsorption studies. The experiments conducted for 2 h and 1 h for Cd(II) and Pb(II) desorption respectively. The results of desorption experiments with various concentrations of HCl or HNO_3 are shown in Table 4.

3.6 Application studies using industrial effluents

Industrial effluent containing Cd(II) and Pb(II) were collected from electroplating unit and battery manufacturing unit located near Kolkata, India. The characteristics of effluent samples were shown in Table 5. Batch adsorption studies were carried out with the collected industrial effluent samples using clarified sludge as metal adsorbent at under under optimum condition as obtained from batch adsorption studies. The final concentration of Cd(II) and Pb(II) fall within the limit of the IS 10500 1992 norms.

4. CONCLUSIONS

In this study, batch adsorption experiments for the removal of Cd(II) and Pb(II) from aqueous solutions have been carried out using clarified sludge

(1) Maximum adsorption of Cd(II) and Pb(II) occurred at pH 5

(2) The experimental data were better described by pseudo 2nd order model as evident from correlation co-efficient (r^2) and χ^2 values for both the metal ions.

(3) The effective diffusion co-efficient of Cd(II) and Pb(II) adsoption process were 2.3×10^{-11} m^2/s and 4.873×10^{-10} m^2/s respectively.

(4) Langmuir adsorption isotherm model was better fitted than Freundlich adsorption isotherm model for Cd(II) but it was reverse for Pb(II) adsorption. The monolayer adsorption capacity were obtained 36.23 mg/g and 92.51 mg/g for Cd(II) and Pb(II) adsorption respectively. (5) Sorption energy for the Cd(II) and Pb(II) were 11.03 kJ/mol and 9.902 kJ/mol respectively which indicated that adsorption process were chemical adsorption in nature.

(6) Thermodynamic parameters studies showed that both Cd(II) and Pb(II) adsorption were spontaneous in

nature. The enthalpy change of the adsorption indicated that process were exothermic for Cd(II) and endothermic for Pb(II) removal.

NOMENCLATURE

B = Langmuir constant (Lmg^{-1})
C_{abs} = Conc. of metal ion on adsorbent at equilibrium, (mgL^{-1})
C_e = Conc. of metal ion in solution at equilibrium, (mgL^{-1})
C_0 = Initial conc. of metal ion in solution, (mgL^{-1})
C_t = Conc. of metal ion in solution at time t, (mgL^{-1})
K_2 = Pseudo-second-order rate constant of adsorption [(mg/g) min]
K_{ad} = Lagergren rate constant, (min^{-1})
K_c = Thermodynamic equilibrium constant
K_f = Measure of adsorption capacity, (mg/g)
K_{id} = Intra-particle rate constant, [(mg/g) $min^{1/2}$]
K_{bq} = Constant obtained by multiplying q_{max} and b
M = Metal ion in Equation (9)
n = Freundlich constants, intensity of adsorption
q = Amount adsorbed per gm of the adsorbent, (mg/g)
q_e = Amount adsorbed per g of adsorbent at equilibrium, (mg/g)
q_{max} = Maximum adsorption capacity, (mg/g)
q_t = Amount adsorbed per g of adsorbent at time t
r^2 = Correlation coefficient
S_s = External surface area of adsorbent per unit volume, (m^{-1})
D_e = Diffusion coefficient (m^2/s)
t = Time, (min.)
F(t) = Amount adsorbed per g of adsorbent at time/amount adsorbed per g of adsorbent at equilibrium
X_m = Maximum adsorption capacity, (mmol/g)
E = Mean sorption energy, (kJ /mol)
ΔG^0 = Gibbs free energy, ($kJmol^{-1}$)
ΔH^0 = Heat of adsorption, ($kJmol^{-1}$)
ΔS^0 = Entropy of adsorption, ($kJK^{-1}mol^{-1}$)

Greek letter

β = mass transfer coefficient, (m/s)
λ = constant related to energy (mol^2/kJ^2)
ε = Polanyi potential (kJ^2/mol^2)

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Adsorptive Removal of Cr(VI) from Aqueous Solution Using Abundantly Available Rice Waste - Kinetic, Equilibrium and Thermodynamic Studies

B. Singha, T. K. Naiya, S. N. Mandal*, A. K. Bhattacharya and S. K. Das

Abstract*— *Hexavalent chromium is a major water pollutant from industrial effluent whose concentration is to be reduced within permissible limits. Rice waste, a cheaply available adsorbent used for the removal of Cr(VI) from aqueous solution. Present study reports a systematic evaluation of rice straw and rice bran as low cost silica based adsorbent for the removal of Cr(VI). Studies were carried out at 303 K to find out the effect of initial pH, initial metal ion concentration, adsorbent dosage and equilibrium contact time for the adsorption process. The optimum pH for the adsorption was 2 for both rice straw and rice bran. Maximum adsorption capacities assuming monolayer adsorption were 12.172 and 12.341 mg/g for rice straw and rice bran respectively. Rate kinetics for the adsorption was studied to understand the mechanistic steps for the adsorption process. Kinetic data was better described by pseudo second order model. Adsorption isotherm of Cr(VI) was better described by Freuindlich adsorption isotherm model. The thermodynamic studies indicated that the process of adsorption was spontaneous and endothermic in nature.

***Keywords*— Rice straw, Rice bran, Freundlich, Pseudo second order, Gibbs free energy.**

1. INTRODUCTION

Cr(VI) is considered to be non biodegradable and have great environmental, public health and economic impacts. Cr(VI) is present in the effluent produced during the electroplating, leather tanning, cement, mining, dyeing, fertilizer and photography industries etc. Cr(VI) has been reported to be toxic to animals and humans. It is also known to be carcinogenic [1].

The concentration of Cr(VI) in industrial waste water varies in the ranges from 0.5 to 270 mg/L [2]. The maximum permissible limit of Cr(VI) for discharge into inland surface water is 0.1mg/L and in potable water is 0.05 mg/L [3], [4]. In order to comply with this limit, it is essential that industries treat their effluents to reduce the Cr(VI) concentration in water and waste water to acceptable levels before its transport and cycling into the natural environment. Several methods are utilized to remove Cr(VI) from industrial waste water. The advantage and disadvantage of these methods are shown in Table 1[5]-[12].

Adsorption is by far most versatile and effective method for such removal, especially, if combined with appropriate regeneration steps. In this study rice straw and rice bran, agricultural wastes were used to remove Cr(VI) from aqueous solution. Factors affecting the adsorption characteristics such as initial pH, contact time, adsorbent dosage and initial Cr(VI) ion concentration were studied. Rate kinetics and isotherm models were also investigated to know the adsorption behavior of the adsorbents considered for study.

2. EXPERIMENTAL

Adsorbents used and preparation

Rice straw and Rice bran - The adsorbents were collected from Shyampur, Howrah, West Bengal, India. All the adsorbents were boiled with distilled water for 7 hr to remove colored materials from it and filtered. Then the adsorbents were dried at 105^0 for 6 hr to remove the adherent moisture, sieved to obtain particle size of 250-350µm and them kept in desicators.

Adsorbent and reagent

All the chemicals used were of analytical grade and purchased from E. Merck Limited, Mumbai, India. The stock solution containing 1000 mg/L of Cr(VI) was prepared by dissolving 3.73 g of AR grade K_2CrO_4 , $2H_2O$ in 1000 ml of de-ionized, double distilled water. Required initial concentration of Cr(VI) standards were prepared by appropriate dilution of the above stock Cr(VI) standard solution.

Batch adsorption studies

The quantitative amount of adsorbents were taken in a 250 ml stopper conical flask containing 100 ml of desired concentration of the test solution at the desired pH value, contact time and adsorbent dosage level. The pH of the solution was measured with a EUTECH make digital microprocessor based pH meter previously calibrated with standard buffer solutions. The contents in the flask were shaken for the desired contact time in an electrically thermostated reciprocating shaker @ 110-125 strokes/minute at 30^0C. The contents of the flask were filtered through filter paper and the filtrate was analyzed for remaining Cr(VI) ion concentration by UV visible spectrophotometer (Model No. U-4100 spectrophotometer, Hitachi, Japan) [13].

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3. RESULTS AND DISCUSSION

Effect of pH on Cr(VI) adsorption

Figure1 shows the percentage removal of Cr(VI) as a function of pH. It is clearly evident that the adsorption characteristics of the adsorbents are highly pH dependent. The percentage removal reached a maximum value at an initial pH of the solution at 2.

Effect of contact time

The influence of contact time on the batch adsorption of Cr(VI) ion at 30^0C, optimum pH and adsorbent dosage is shown in Figure 2. It is obvious that increase in contact time, the percent removal of Cr(VI) enhanced significantly. This figure is indicated that the equilibrium was reached at 3 hr. for rice straw and 5 hr. for rice bran.

Effect of adsorbent dosage

Figure 3 shows the variation of adsorbent dosage on the percentage removal of Cr(VI) from aqueous solution using initial metal ion concentration at 25 mg/L. The efficiency of Cr(VI) removal was found to increase rapidly at adsorbent dosage from 1g/L to 7.5 g/L. Further increasing the adsorbent dosage above 10 g/L, the removal efficiency almost remained constant. It was evident that for all the aforesaid adsorbents maximum removal efficiency was achieved at an adsorbent dosage level of 10 g/L which may be considered as an optimum adsorbent dosage level.

Effect of initial Cr(VI) ion concentration

The effect of initial metal ion concentration on the removal of Cr(VI) is shown in Figure 4. Percent removal of Cr(VI) ion decreases with increasing in initial Cr(VI) ion concentration. At the lower concentration, all the Cr(VI) ions in the solution would react with the binding sites and thus facilitated almost complete adsorption.

Adsorption kinetics study

The rate kinetics of Cr(VI) adsorption were analyzed using different kinetic model as follows

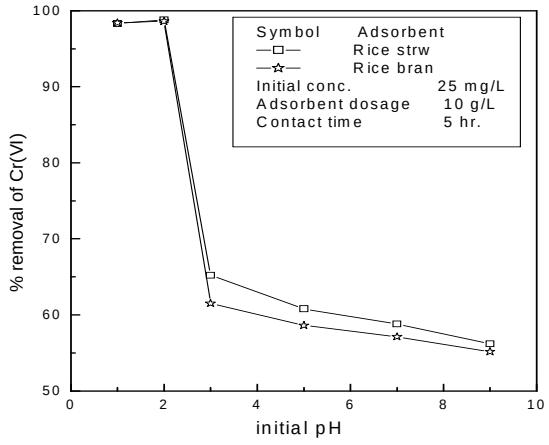

Figure 1 Effect of pH on Cr(VI) removal

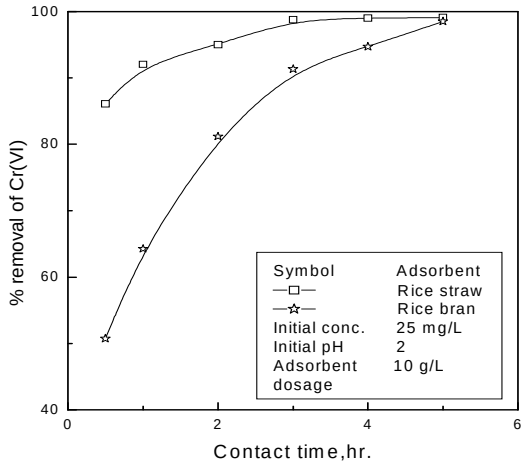

Figure 2 Effect of contact time on Cr(VI) removal

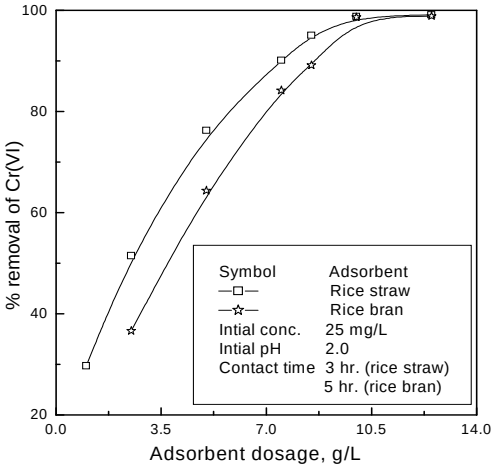

Figure 3 Effect of adsorbent dosage on Cr(VI) removal

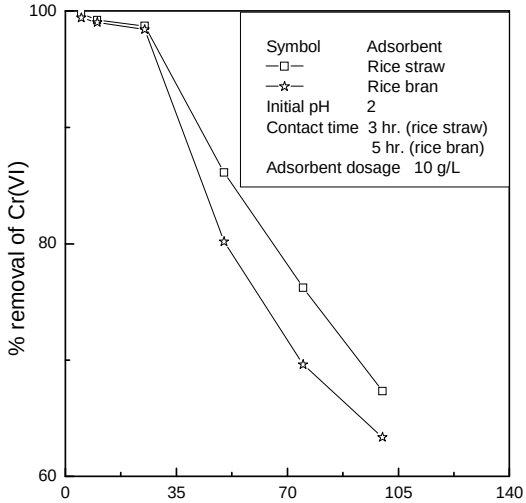

Figure 4 Effect of initial conc. on Cr(VI) removal

Table 1: Some Conventional method of removal of heavy metal (Advantage/ Disadvantage)

Removal process	Advantage	Disadvantage
Coagulation-precipitation-filtration	Comparatively cheap	i) Process is complicated ii) Disposal of precipitated heavy metal hydroxides poses a major problem iii) Insufficient to meet requirement when present in low concentration
Resin ion exchange	i) Removal of metal at low concentration ii) Simplifies the equipment and operation	i) Low selectivity of metal ion except using chelating resins ii) Resins are expensive
Membrane separation	i)Effective simple technique ii) Greater selectivity	Very much expensive
Cementation	Greater selectivity	i) Production of toxic sludge or waste product ii) High operational cost
Sedimentation	i) Simple technique ii) Greater selectivity	i) Incomplete removal ii) Production of toxic sludge or waste product
Adsorption using activated carbon	i) High adsorption capacity ii) Greater selectivity iii) Fairly uniform	i) High capital investment ii) High regeneration cost
Adsorption using natural adsorbents	i) High adsorption capacity ii) Low cost iii) Local availability	

Table 2 Rate Kinetics for adsorption of Cr(VI) ion by different adsorbents

Adsorbents	Lagergren 1st Order model		Pseudo 2nd Order model	
	K_{ad} (min^{-1})	r^2	K_2 [(mg/g)min]	r^2
Rice straw	0.027	0.975	0.072	0.999
Rice bran	0.019	0.957	0.009	0.998

Pseudo first order Lagergren model

The pseudo first order kinetic model was proposed by Lagergren [14]. The integral form of the model generally expressed as follows

$$\log(q_e - q) = \log q_e - \frac{K_{ad} t}{2.303} \quad (1)$$

Pseudo second order model

The linearized form of pseudo second order kinetic equation [15] is expressed as

$$\frac{t}{q} = \frac{1}{K_2 q_e^2} + \frac{1}{q_e} t \quad (2)$$

Lagergren and Pseudo second order models are presented in Figures 5 and 6 respectively. The values of rate constants and correlation coefficients for each model are shown in Table 2. The high correlation coefficients (r^2) values were indicated that the adsorption of Cr(VI) onto rice straw and rice bran follow pseudo second-order model than that of pseudo first-order model.

Isotherm model

For the analysis of equilibrium data for Cr(VI) adsorption onto rice straw and rice bran, the following isotherm models are used

Langmuir isotherm model

The data obtained from adsorption study was fitted to the Langmuir adsorption isotherm as [16]

$$\frac{C_e}{q_e} = \frac{1}{q_{\max} b} + \frac{C_e}{q_{\max}} \quad (3)$$

The values of Langmuir constants and correlation coefficients (r^2) obtained from Figure 7 are shown in Table 3. Linearity of the plots indicated the applicability of the adsorption isotherm. The maximum adsorption capacities for the adsorption onto rice straw and rice bran were 12.172 mg/g and 12.341mg/g respectively.

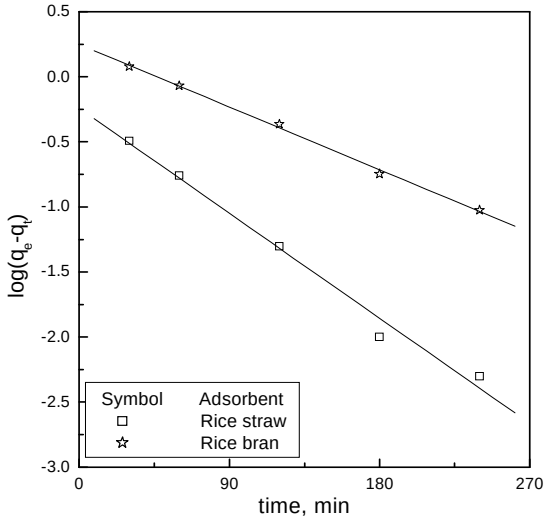

Figure 5 Lagergren plot for adsorption of Cr(VI)

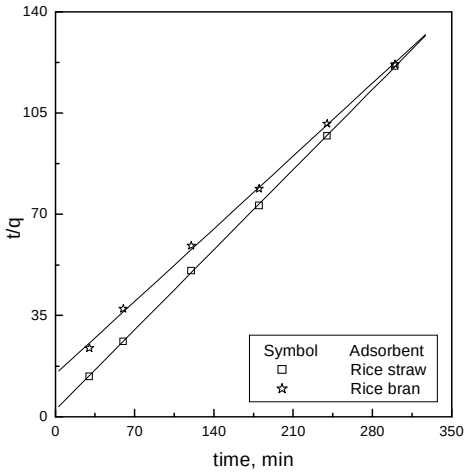

Figure 6 Pseudo second order plot for adsorption of Cr(VI)

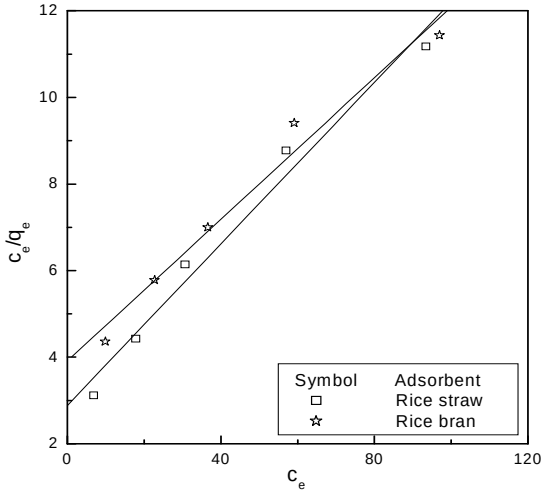

Figure 7 Langmuir plot for adsoption of Cr(VI)

Freundlich isotherm model

The adsorption data obtained was also fitted to the Freundlich adsorption isotherm as [17]

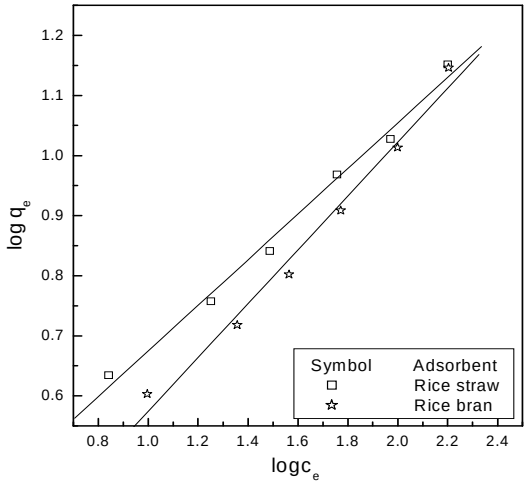

Figure 8 Freuindlich plot for adsorption of Cr(VI)

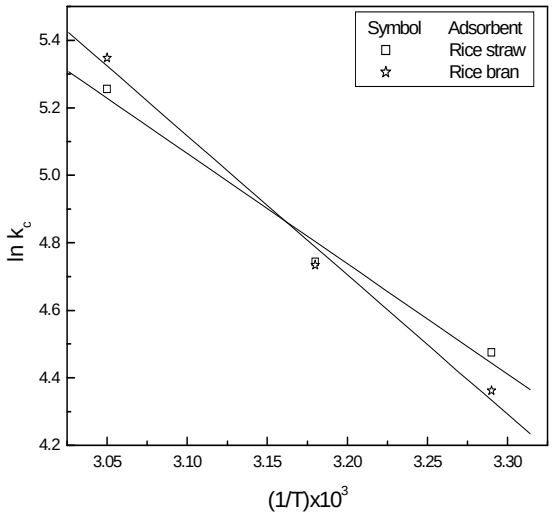

Figure 9 Determination of thermodynamic parameter

$$\log q_e = \log K_f + \frac{1}{n}\log C_e \qquad (4)$$

The values for Freundlich constants and correlation coefficients (r^2) obtained from Figure 8 are shown in Table 3. From the value of correlation coefficients (r^2), it can be concluded that the adsorption of Cr(VI) onto rice straw and rice bran follow Freundlich adsorption isotherm model.

Thermodynamic parameters for adsorption

The effect of temperature was investigated at 30, 40 and 55^0C at optimum pH value of 2 and adsorbent dosage level 10 g/L.

The thermodynamic equilibrium constant (K_c^0) for each adsorbent was calculated by determining the apparent equilibrium constant, $K_c^{'}$ at different initial concentration of Cr(VI) and extrapolating to zero.

Table 3 Langmuir and Freundlich adsorption isotherm constants for Cr(VI) on different adsorbents

Adsorbents	Langmuir Constants			Freundlich Constants		
	q_{max} (mg g^{-1})	B (L mg^{-1})	r^2	K_f (mg/g)/(mg/L)$^{1/n}$	n	r^2
Rice straw	12.172	0.183	0.980	2.713	3.018	0.993
Rice bran	12.341	0.064	0.947	2.136	3.041	0.954

Table 4 Thermodynamic parameters for the sorption of Cr(VI) onto adsorbents

Adsorbent	ΔH^0 (kJ/mol)	ΔS^0 (kJ/mol)	T (K)	$-\Delta G^0$ (kJ/mol)
Rice straw	26.124	0.104	303	5.538
			313	6.407
			328	8.131
Rice bran	38.547	0.144	303	5.248
			313	6.385
			328	8.828

Table 5 Comparison of adsorption capacities of the adsorbents

Serial no.	Adsorbents	Adsorption capacities for Cr(VI) (mg/g)	Reference
1	Leaf mould	43.1	[18]
2	Beech sawdust	16.1	[18]
3	Sugarcane bagasse	13.4	[18]
4	Eucalyptus bark	45.00	[19]
5	Rice straw	3.15	[20]
6	Sawdust	20.70	[21]
7	Neem bark	19.60	[21]
8	Rice husk	8.5	[22]
9	Rice straw	12.172	[Present study]
10	Rice bran	12.341	[Present study]

$$K_c^{'} = \frac{C_a}{C_e} \quad (5)$$

The Gibbs free energy, ΔG^0, enthalpy, ΔH^0, and entropy, ΔS^0 were computed using following equation

$$\Delta G^0 = -RT \ln k_c \quad (6)$$

$$\ln k_c = -\frac{\Delta H^0}{RT} + \frac{\Delta S^0}{R} \quad (7)$$

The value of standard free energy, ΔG^0, was calculated using Equation (6). The value of slope and intercept of the plot $\ln k_c$ vs 1/T (Figure 9) gave standard enthalpy, ΔH^0, and standard entropy, ΔS^0, respectively (Table 4). Negative value of, ΔG^0, at all temperatures indicated the spontaneous nature of the adsorption. Positive values of enthalpy change suggested the endothermic nature of the adsorption process. Positive values of entropy change also indicated the increased randomness at solid/solution interface during the adsorption process.

Comparison of adsorption capacity with different adsorbents reported in literature

The adsorption capacity of Cr(VI) onto rice straw, rice bran were compared with other adsorbents reported in literature and is shown in Table 5. The adsorption capacity varies and it depends on the characteristics of the individual adsorbent, the extent of surface modification and initial concentration of the adsorbate.

4. CONCLUSIONS

The optimum pH for the removal of Cr(VI) was found to be 2. Increase in the concentration of adsorbent dosage and contact time, the percentage removal of Cr(VI) were increases whereas increase in initial Cr(VI) concentration, percentage removal decrease. The kinetics of the Cr(VI) adsorption on different adsorbents was found to follow pseudo second order rate mechanism. Adsorption isotherm of Cr(VI) was better described by Freuindlich adsorption isotherm model. The negative values of Gibbs free energy for the adsorption process reveal that the process is spontaneous. The standard

enthalpy change for the adsorption indicated that the process is endothermic. Rice waste can be used as an effective natural adsorbent for the economic treatment of waste water containing Cr(VI).

NOMENCLATURE

b	Langmuir constant(L/ mg)
C_a	concentration of Cr(VI) after certain period of time (mg/L)
C_e	concentration of Cr(VI) in solution at equilibrium (mg/L)
ΔG^o	Gibbs free energy (kJ/mol)
ΔH^o	enthalpy of adsorption (kJ/mol)
K_{ad}	Lagergren rate constant (min^{-1})
$K_c^{'}$	apparent equilibrium constant
K_f	measure of adsorption capacity(mg/g)
K_c^0	thermodynamic equilibrium constant
K_2	pseudo second order rate constant [(mg/g)min]
n	Freundlich constants, intensity of adsorption
q	amount adsorb per gm of the adsorbent (mg/g)
q_e	amount adsorb per gm of the adsorbent at equilibrium (mg/g)
q_{max}	maximum adsorption capacity(mg/g)
r^2	Correlation coefficient
R	universal gas constant (kJ/mol/K)
ΔS^o	entropy of the adsorption (kJ/mol)
t	time (min)
T	absolute temperature (K)

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How is Thai Industrial Location Policy Get Beneficiary under GMSECs?

Apisek Pansuwan* and Kritsana Kityuttachai

Abstract— *It can be best explained that although industrial development that Thailand has escalated the country to Newly Industrialized Country, it still fails to disperse industries to its regions. Such failure has been resulted from the deep-seated cause of the Industrial Magnitude of Bangkok Metropolitan Region or BMR; consequently, the BMR leads the country to income disparity and chronic poverty between people in Bangkok and in rural area. This paper provides a descriptive analysis of the changes in industrial structure and spatial concentration that has occurred in Thailand over the period from1996 to 2005. The location quotient was used to measure its regional specialization. Using this property, it was found that, the decrease in the spatial concentration of manufacturing occurred in Thailand remained stable or lower in a small degree. This indicated that the industrial decentralization policy was less successful. However, some factories were relocated into the GMSECs strategic area, especially economic corridor and logistic route significantly.*

***Keywords*— GMSECs, BOI, Industrial Location Policy, Manufacturing Structure in Thailand.**

1. INTRODUCTION

Despite the success of industrialization over years, little emphasis has been placed on the dispersion of industries to rural areas [7, 9]. The industrialization policy and strategy stressed on the importance of import substitution and export oriented industries. As a result, most of the industrialization took place in and around Bangkok Metropolitan Region (BMR) as the economically most efficient location for import substitution and export oriented industries. The concentration of factories in Bangkok then led to mass migration into the capital and ended up with social ills such as slums, environment pollutions, traffic congestion and income disparities [4, 10].

In spite of the problems of congestion and pollutions resulting from the intense concentration of industrial activities, it is found that many factories are still located in the BMR; therefore the fruits of industrialization have not been widely and evenly spread to other regions [6, 9]. Most provinces outside of BMR still depend heavily on activities related to agriculture, whereas incomes remain limited. As shown in Fig.1, the result of industrial concentration effected in BMR precisely shows that in 2005. The disparity of gross regional products (GRP) per capita between BMR, the highest level stood at 275,030 Baht/year, and Northeastern, the lowest level stood at 32,897 Baht/year still remains high. The difference was 8.4 times. This income disparity was resulted from production in manufacturing and other non-agriculture sectors [3].

2. LITERATURE REVIEW

Industrial Location Policy

Industrial development in Thailand has resulted in economic imbalance and inequality because of the primacy of Bangkok which is among the most primate cities in the world. Its population is 4 times larger than that of the second largest city in Thailand. Bangkok is the centre of population, government, and economic activities [2]. One of the rationale motivating industrial policies of Thailand is to mitigate the consequences from the growth of Bangkok where is the centre of Thailand's economy.

Primate city predominance has become a concern for two reasons. First, Bangkok as a primate city has increased regional inequality in Thailand. Second, infrastructure bottlenecks have necessitated the expansion of industry on the perimeters of the capital city. Further, the pattern of regional expansion appears to be influenced by BOI investment zoning policy. Industrial decentralization is an important tool for creating regional equality. Thus, the Thai government has actively pursued industrial decentralization since 1987, using several initiatives including BOI incentives, financial incentives, and industrial estates like the Eastern Seaboard Development Programme. The locational incentives in government policy may also promote the deconcentration of industrial activity within the greater BMR.

The BOI and the Industrial Estate Authority of Thailand (IEAT) are the primary government agencies shaping industrial location policy. The IEAT oversees industrial estates sponsored by government while the BOI provides incentives based on the type and location of the firm. Most government investment in infrastructure for industry has been in the form of

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industrial estates (IEs). This method of infrastructure distributing may be biased against the decentralization of industrial growth. In 1987, BOI incentive zoning policy changed drastically. Three promotional zones (Fig. 4) were established. Zone 1 included Bangkok and Samut Prakarn; Zone 2 included the inner ring provinces (Nakhon Pathom, Nonthaburi, Pathum Thani, and Samut Sakorn); and Zone 3 comprised, all remaining provinces. With this change, the firms in Zone 1 received no corporate income tax holiday unless they met export or employment targets [2].

The BOI took a more progressive stance towards industrial deconcentration in its 1993 update of Criteria in Approving Investment Promotion and Providing Tax Privileges. In 1993, sectoral restrictions became much stricter based on the proposed location of the firm seeking benefits. For the first time, certain industries would no longer be promoted if they are located in Zone 1, even if they were primarily exporters. For example, only textile producers located in Zone 3 are entitled to promotion, while electronics firms locating in either Zone 2 or Zone 3 are entitled to promotion. Many types of resource-based industries, light industries, metal products and machinery, electronics, and chemical, paper and plastics industries can only receive BOI promotion by locating in Zone 2 or even Zone 3. (There appear to be exceptions for some exporting firms located in industrial estates in Zone 1 . However, the IPZs were revised again in 2000 [3].

GMSECs Framworks and Effect on Thailand Industry

Greater Mekong Subregion (GMS) is a country group located in Mekong River basin and sharing natural resources in Mekong River. The GMS comprises of six countries namely; Kingdom of Cambodia, Lao People's Democratic Republic, Myanmar, the Kingdom of Thailand, the Socialist Republic of Vietnam, and the People's Republic of China (Yunnan and Guangxi Province). Since 1992, the GMS countries have embarked with the assistance of Asian Development Bank (ADB), these nations have cooperated in economic programs, and environmental protection through closer economic linkages. With the aim to effectively manage the environment and economic development in GMS through enhanced connectivity, improved competitiveness, and community in the subregion to reach the sustainable development, the life quality of GMS people is better. The cooperation under the GMS countries' Strategic Development Framework aims to develop the investment, logistics, tourism, agriculture, telecommunication, capability building, energy, environmental management, infrastructure, and commerce in subregion.

Thailand's geographical site is an advantage as it is the heartland of subregion: the hub or center of logistics in the GMS, so the Government of Thailand has supported to develop the transportation network to link with neighboring countries in the area as the regional freight transport. The GMS economic corridors can enhance connectivity of GMS communities by the linkage or exchanging knowledge, science, arts, culture, technology, goods, and services. All of them play as the indicators for socio-economic development of the sub region. There are three main economic corridors (Fig.2) to link the subregional transport and socio-economy, namely; North-South Economic Corridor (NSEC), East-West Economic Corridor (EWEC) and Southern Economic Corridor (SEC).

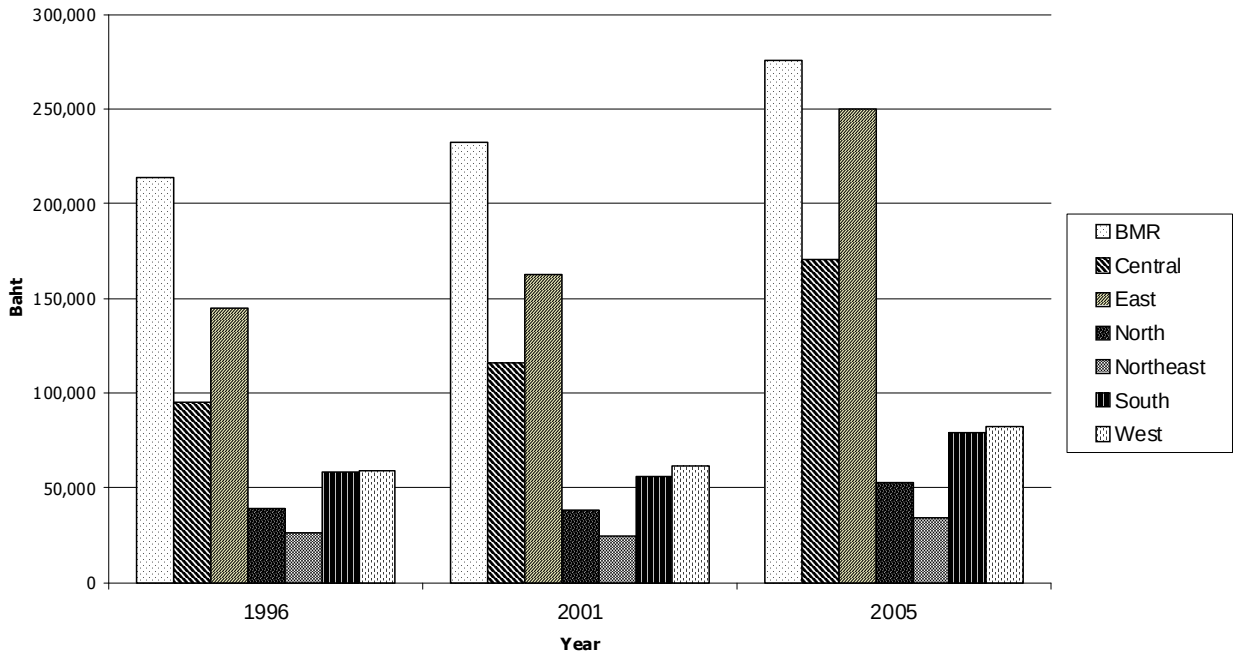

Fig. 1. Gross Regional Product Per Capita, by region 1996-2005
Source: Calculated from NESDB (2007)

Fig. 2. GMS Economic Corridors (GMSECSs)
Source: ADB, 2002 from [1]

In Addition, the influence corridors that have the most effect on Thailand's economic are the North-South Economic Corridor and the East-West Economic Corridor. Besides, Thailand is the hub where NSEC and EWEC join together at Wang Thong intersection in Phitsanulok province. In comparison with other GMS countries located in these corridors, half of the whole distances of both NESC and EWEC passes over Thailand. This will become a logistic route that will positively affect the economy of Thailand.

The geographical advantage affects Thailand as a center of regional freight transport either NSEC or EWEC. It reduces the transportation distances of neighbor countries such as China; Lao PDR can transfer freight to deep port around the Gulf of Thailand. Goods and services are distributed to other regions through the hub as Thailand especially Bangkok is the center of the industrialization and logistics.

3. METHODOLOGY

The data set we use is the industrial database provided by the Department of Industrial Work (DIW), Ministry of Industry. It includes data for 76 provinces and 11 manufacturing sectors registered directly by the DIW. The time focused (1996-2005) is the period which cover pre- and post financial crisis period.

The regional specialization indices are the measure of the degree of industrial specialization (or diversification) of a region. Changing in these indices indicate changes in the industrial structure of the region. Location Quotient (LQ), sometimes called coefficient of localization or specialization, is a ratio that approximates the relative position of an activity in an area as compared to the same activity occurring in a broader region. The formula for computing location quotients is defined as:

$$LQ_i = \frac{A_i}{\sum_{i=1}^{n} A_i} \Big/ \frac{B_i}{\sum_{i=1}^{n} B_i}$$

where:

A_i = the amount of some activity A in area i

B_i = the measure of activities A in the whole region i

Location quotients can be interpreted by using the following conventions:

1. If LQ>1, this indicates a relative concentration of the activity in area *n*, compared to the region as a whole.
2. If LQ =1, the area has a share of the activity in accordance with its share of the base.
3. If LQ<1, the area has activity share less than that has been generally, or regionally, found.

4. FINDINGS

GMSECs Survey

Basically, NSEC has 2 routes (see Fig. 1), the first one is from Kunming city, China (PRC) to Bangkok and the second one is from Kunming to Hanoi, Vietnam. The NSEC where directly affects Thailand is along the route number R3A from Kunming – Xishuangbanna- Mohan in China (PRC) cross border to Boten (Lao PDR)-Luang Namtha-Huaixay then cross the Makong River to Chiang Khong Distrcit,Chiang Rai province in Thailand and goes along the road no. 1020, 1152 and 1232 joins the expressway no.1 Phahon Yothin in Chiang Rai then goes downtown to Bangkok.This route passes over 13 provinces: Chiang Rai, Phayao, Lampang,Phrae, Uttaradit, Phitsanulok, Phichit, Nakhon Sawan, Lop Buri, Sara Buri, Ayutthaya, and Phathum Thani to Bangkok. The total distance of NSEC from Kunming to Bangkok is about 1,960 Km as shown in Table1 and Figure 3.

The EWEC is an economic route as economic development plan in Greater Mekong Subregion. This logistic route aims to link the economic region from the Western coast area of Andaman Sea to the Eastern coast area of the South China Sea. EWEC start from coastal route in Mawlamyine, Myanmar cross border to Mae Sot border goes along the road no.105 to Tak downtown joins road no. 12 to Sukohthai, Phitsanulok, Phetchabun, Chaiyaphum, Khon Kaen, Kalasin, and Mukdahan province, then crosses the Mekong River to Sawannakhet District in Lao PDR along the road no.9 entering Densavan/Lao Bao Border (Lao PDR/Vietnam border) passes over Dong Ha town in Quang Tri province to Hue city in Thua Thien province until to the end at the coastal area of Da Nang, the fourth largest city of Vietnam. The

total distance from Da Nang, Vietnam to Mawlamyine, Myanmar about 1,432 Km. is given in Table 2 and Fig. 3.

Table 1. NSEC distances by country

Country	From - To	Length (km)	Percentage
PR China	Kunming,Yunnan–Mohan/Boten(China /Lao Border)	760	39
Lao PDR	Mohan/Boten(China /Lao Border) - Huaixay (Lao PDR)	225	11
Thailand	**Chiang Khong, Chiang Rai - Bangkok (Victory Monument)**	**975**	***50***
	NSEC Total	1,960	100

Source: Field Surveyed, September 2007.

Table 2. EWEC distances by country

Country	From - To	Length (km)	Percentage
Vietnam	Da Nang, Vietnam - Lao Bao/Densavan Border (Vietnam/ Lao PDR border)	266	19
Lao PDR	Lao Bao-Densavan Border - Sawannakhet	236	16
Thailand	***Mukdahan - Mae Sot Border, Tak***	***805***	***56***
Myanmar	Myawaddy - Mawlamyine	125	9
	EWEC Total	1,432	100

Source: Field Surveyed, June 2007.

Table 3 Change in the Structure of Manufacturing Industry in Employment

Sector	1996		2005		Growth	Growth rate
	Number	% Share	Number	% Share	1996-2005	(%)
Food, Beverages and Tobacco	442,343	17.93	574,412	16.55	132,069	3.32
Textiles, Wearing Apparel, Leather Products	558,520	22.64	727,919	20.97	169,399	3.37
Paper and Paper Products, Printing	60,672	2.46	98,504	2.84	37,832	6.93
Chemicals and Chemical Products	68,631	2.78	106,595	3.07	37,964	6.15
Rubber and Plastic Products	195,447	7.92	333,688	9.61	138,241	7.86
Non-Metallic Mineral Products	146,587	5.94	193,099	5.56	46,512	3.53
Basic Metals and Fabricated Metal Products	191,299	7.76	231,793	6.68	40,494	2.35
Machinery, Electrical Equipment and Supplies	285,493	11.57	460,307	13.26	174,814	6.80
Motor Vehicles and Other Transport Equipment	149,809	6.07	367,299	10.58	217,490	16.13
Furniture	168,665	6.84	226,337	6.52	57,672	3.80
Other Manufacturing Industries	199,191	8.08	150,832	4.35	-48,359	-2.70
Total	2,466,657	100.00	3,470,785	100.00	1,004,128	4.52

Source*: DIW (2005)*

Table 4 Change in the Geographical Distribution of the Manufacturing Industry in Employment by BOI's Zone

Zone	1996		2005		Growth	Growth rate
	Number	% Share	Number	% Share	1996-2005	(%)
1	1,352,470	54.83	1,656,697	47.73	304,227	2.50
2	447,693	18.15	819,984	23.63	372,291	9.24
3	666,494	27.02	994,104	28.64	327,610	5.46
Nation	2,466,657	100.00	3,470,785	100.00	1,004,128	4.52

Source*: DIW (2005)*

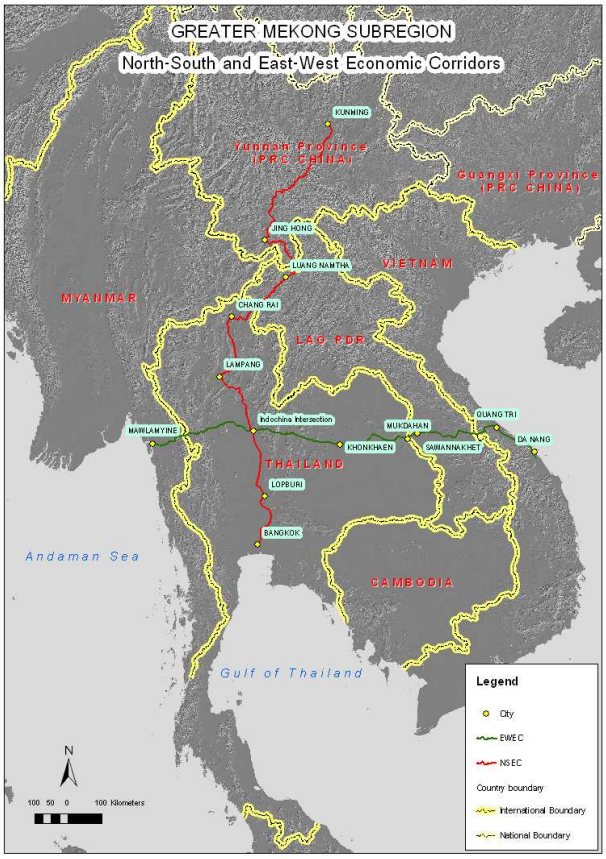

Fig. 3. North-South and East-West Economic Corridors.

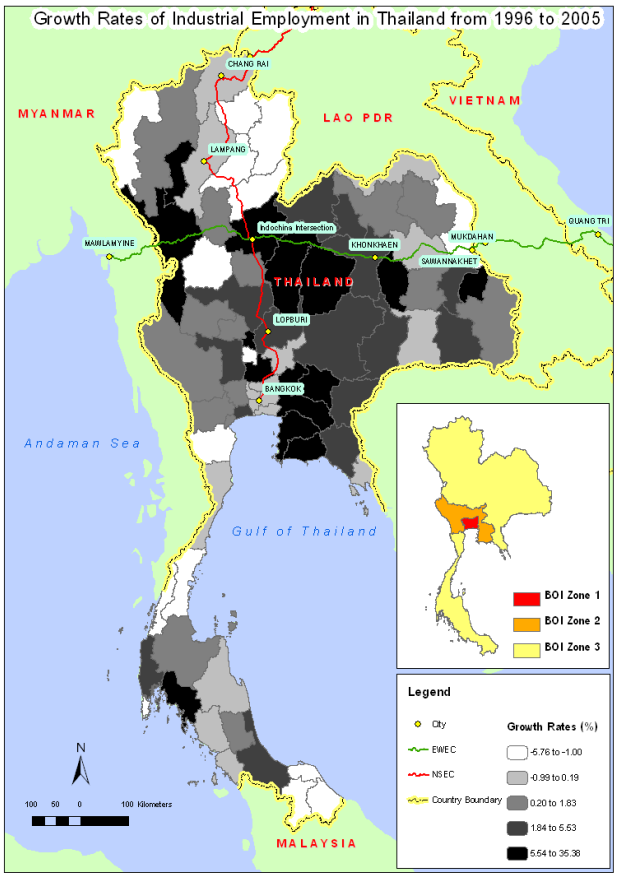

Fig. 4. Growth rates of Industrial Employment in Thailand from 1996 to 2005

The Manufacturing Structure and Distribution in Thailand

Table 3 indicates the changes in the structure of the manufacturing industry between 1996 and 2005. Thailand as a whole had the annual employment contract at the average rate of 4.52% over the period, increasing above 1 million employees altogether (from 2.46 million to 3.47 million employees). The motor vehicle and other transport equipment recorded the largest positive growth rate at 16.13%. It increased 217 thousand employees, accounting for 25% of the total increase in manufacturing employment. Therefore, it increased its employment share substantially from 6.07% to 10.58% during the period. This reflects the fact that Thai government has promoted the hub of auto-mobile as 'Detroit of Asia' since the early 1990s. In 2005, the textile, wearing apparel and leather products still had the largest employment share at 20.97%, followed by the food, beverages and tobacco products at the percentage of 16.55. Machinery, electrical equipment and supplies industries enjoyed 13.26% of the share.

From the location quotient of regional specialization analysis during 1996 to 2005. In 1996, it was found that 12 of the 20 provinces with specialization in manufacturing industry were located in the core region (Zone1 and 2). In 2005, Bangkok had stilled the highest specialization which however was decreased. Only 12 of the 76 provinces showed an increase in higher specialization, and most of them were located in the core region, especially in the vicinity and inner ring area; Nakhon Pathom, Nonthaburi, Samut Sakhon, Chachoengsao, Phra Nakhon Si Ayutthaya, and Rayong where were the important sources of food processing, electronic appliance, auto-mobile and chemical production while 5 of the 58 provinces in the promotional area by BOI showed an increase in specialization, but the magnitude of this increase was very small.

Table 4 has shown the change in the geographical distribution of the manufacturing by region between 1996 and 2005. There have been significant changes in the geographical distribution. Among the 3 zones, 2 zones presented above average annual growth rate of the nation, especially, Zone 2, where includes Chon Buri and Rayong as the center of petro-chemical and auto-mobile industries and business in the eastern region of Thailand, recorded very high positive growth rates (above 2 times of the nation). In 2005, Zone 2 had around 23.63% of total manufacturing employment higher from 18.15% in 1996. It raised 372 thousand manufacturing employees in the period. The Zone 1, where BMR was included, also had higher rate of employment, but slightly growing. However, only Bangkok had lost its share from 21.70% to 14.41% of the total manufacturing employment. It recorded negative growth rates around -0.72%, whist its vicinity showed positive growth rates such as Samut Prakan and Samut Sakhon, increased above 151 and 94 thousand of manufacturing employment respectively.

5. DISCUSSION

Finally, there seems to have a shift in manufacturing employment, during 1996 to 2005, from the industrial core to the inner ring area, even though the BMR still occupied 47.73% of total manufacturing employment. It should be noted that the relocation of factory during the late 1990s and the early 2000s, which corresponds closely to the rise and the collapse of the bubble economy. In early 1990s, financial institutes increased their loan for investment in stocks and real estate, especially in BMR, following the deregulation and liberalization of financial sector in Thailand. As a result, the prices of stocks and real estate increased conspicuously, and their respective capital gain brought huge wealth to the investors. However, this bubble economy collapsed in 1997 with a drastic fall in the prices of stocks and real estate so called 'Tom Yam Kung Crisis' and the Thai economy entered a period of recession. Actually, the financial crisis was associated with the rise and fall of geographical concentration in BMR.

Although, almost of factories were still located in the BMR, the industrial employment in some provinces under the GMSECs grew rapidly for example Tak, Phitsanulok, Lamphun and Khon Kaen. Their employment increased about 88,000 persons. Almost of them were in the labor-intensive industries such as the Textile and Electronic industries. The increment indicated that the potential and the opportunity of the strategic area under the GMSECs were useful for the entrepreneurs to operate their transactions and transport costs particularly in the EWEC.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of this study confirmed that the impact of the country's trade liberalization policies has been the industrial concentration and spatial concentration in the BMR. Although the Government of Thailand has also been attempting to promote industrial decentralization policies, still there has been no real and significant evidence of increased regional specialization of manufacturing between 1996 and 2005 in the IPZs specifically in Zone 3. However, many firms have already relocated their industries from the BMR to its surrounding areas covered in Zone 2, more particularly in the IEs by IEAT. Therefore, it can be concluded that the privileges offered under the BOI scheme may have not been really sufficient to subsidize the agglomeration economies in the new economic geography model.

After GMSECs had been embarked on the GMS Strategic Development Framework; the direction of industrial development in Thailand emerged in the positive way. Especially many provinces along the GMSECs were affected by the positive growth rates of employment, espectially in remote areas. Consequently, the economic corridors affect many footloose industries in Thailand to evacuate from BMR to potential area around GMSECs. In the meanwhile, Thailand developing policy that was issued by BOI should be adjusted in the same direction of GMSECs Strategic Development Framework. As BOI's planning policies focused on the tax conventional measure, GMSECs aimed to develop under the geographical development framework in many dimensions. The cooperation embarks through closer economic linkages of the region and harmonizes with the regional developing plan.

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Knowledge Management on Local Wisdom of Tai-so Community Weaving Culture in Phone Sawan District, Nakhon Phanom Province

Weerasak Juladalai, Panitha Yongpithayapong* and Saravut Rachmanee

Abstract— *The objectives of this research were to study i) weaving cotton culture, ii) identifying ways to pass on traditional weaving local wisdom of Tai-So Community. Participatory Action Research : PAR was used with various groups of Tai-So e.g. local wisdom teacher, weaver women, community leaders, educational institutes, religious institutes and Phonjan Sub-district Administration Organization.*

Results indicated that forty years ago traditional weaving has started to disappear from Tai-So communities e.g. cotton cultivation, using indigo-blue for dying, because of paddy fields expansion resulting from increase population. Traditional custom such as "LONGKHUNG KHENFAI" also disappeared from Tai-So communities. With good road connection between Kusumal-Tha-uthen, it brought tradesmen to the communities with commercial dyes, artificial fibers and factory weaving cloths. So no traditional local wisdom of cotton production, dyeing cotton hand weaving has not passed on to the young generation in present Tai-So communities. Furthermore, at present children in these communities commuted to the city or nearby provinces to attend bigger/better schools. Opportunities to pass on local wisdom from old generation to the young are even more slim.

After PAR activities of this project in Phonjan sub-district, Tai-So began to have more awareness about the importance of conservation of the local wisdom, Tai-So culture of weaving traditional cotton cloth. They have established folk museum of Tai-So weaving at Phonsai temple, to bring local wisdom e.g. traditional patterned design weaving and process making it to be a lesson using modern media in various forms at Phonjan school. Furthermore, traditional style weaving products now have been promoted through Tai-So women groups with supports from Phon – Sawan District Municipality and Phonjan Sub-district Administration Organization.

Keywords— Knowledge Management, Community Weaving Culture, Phone Sawan.

1. BACKGROUND

Nakhon Phanom, with a long historical background over thousand years, like other ancient well developed community in Sakhon Nakhon Basin, situated near great river basin: the Songkhram River, the Mekong River. King Rama III appointed Phra Sunthornwongsa to govern Muang Nakhon Phanom and Muang Yasothorn. The Viceroy moved these troops to herd the people from the left-side of Mekong River bank, Laos. Tribes which were consisted of Phuthai, Kha, Kra So or Tai So, Kalerng, Saek, Yor and Yoei were herded from Muang Wang, Muang Pin, Muang Nong, Muang Se-Pone, Muang Kham Kerd, Muang Kham Moeun, Muang Kham Or Kham Khiao, Muang Saek, Muang Chiang Hom, Muang Pha Bung and others. The peoples were forcibly resettled by the government. From the above historical evidence, Nakhon Phanom was consisted of various peoples. (From Culture and History, Identity and Traditional Knowledge Development of Nakhon Phanom, 1999)

Tai-so or Kra-so in Nakhon Phanom is the same ethnic group as Bru or Kha. Anthropologist classified Tai-so as a member of Mongoloid group. They have different language and custom from Kha. Their language is in Austro-Asiatic Language Family Group. Some information on Thai ethnic languages from Language and Cultural Research Institute for Rural Development at Mahidol University described Tai-so. According to the information, Tai-so immigrated to Thailand in King Rama III's reign. The tribe resettled Muang Ramaraj which was Muang Nakhon Phanom's satellite. In B.E.2387, the king appointed Thao Bua of Muang Chieng Hom as Phra Thai Pratet, the first governor. The area, which is Tai-so's community, is now Ramaraj Sub-district, Phra Tai Sub-district, Tha Champa Sub-district of Tha U-tane District and Phone Sawan Sub-district, Ban Khor Sub-district, Na Kamin Sub-district of Phone Sawan District in Nakhon Phanom.

Lots of Tai-so people live at Phone Sawan District in Nakhon Phanom and Kusumal District in Sakon Nakhon. Tai-so's communities at Phone Sawan District wholeheartedly conserve their culture. They believe supernatural powers such as Phi Fa, Phraya Thaen and worship former ancestors which represent Phi Pu Ta. Their distinguished traditional wisdom is their handicraft textiles such as Pha Mud Mee Yom Kram, Pha Keb and cloth for Teen Sin. The textiles are unique to Tai-so. The cloth which has meticulous, colorful, floral patterns was woven by Tai-so's spirit under supernatural powers, Phi Fa. Mostly the weaving is homemade cloth. They make cloth for their uses. Tai-so weaving traditional wisdom transfer mostly do among family members and relatives.

The researchers were invited to attend Tai-so's

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Festival every year. We found Tai-so society has changed by the radio, television and the Internet. This affects Tai-so weaving traditional. Urban culture and western culture are dominating the tradition. Tai-so's youths view their culture as a humble one in Thai culture. From an interview with community leaders and community local wisdom, the people suggested a study on Tai-so weaving traditional and local wisdom by using community participation process.

2. OBJECTIVES

1. To study Tai-so community context at Phone Sawan District, Nakhon Phanom.
2. To study the process of Tai-so's weaving traditional wisdom transfer.
3. To study how to adopt Tai-so's weaving traditional wisdom for producing value-added cultural goods.

3. RESEARCH METHODOLOGIES

3.1. Form of the study

This is a participatory action research for local development.

Tools for this study are Focus Group Discussion, In-depth Interview and observation which allowed the participants to think, plan, act and analyze critically.

3.2. Study Process:

There were five activities for this study process.

Activity I: A survey on Tai-so's traditional wisdom in order to collect background and value of their weaving culture. The researchers spent four months to review some research literature, to interview some Woman Local Weaving Group and some local authorities at Phone Chan Sub-district, Phone Sawan District, and Nakhon Phanom. There are three sub-activities. The sub-activities are as follows:

Activity1.1 collecting data in issues and aspects

Activity1.2 issue analysis and synthesis

Activity1.3 the first report

Activity II: Focus Group Interview was employed in order to study (1) Tai-so's weaving traditional wisdom transfer and (2) ways of this wisdom transfer. The researchers organized learning and sharing forum, participatory sub-group conferences and folk forums. Participants were members of Woman Local Weaving Group, local leaders, local authorities, community development officers, local government agents. It took 3 months for this activity.

Activity III: The researchers organized weaving traditional wisdom returning to the community by collecting, managing and diffusing some knowledge to the general public. This activity help the people to access the knowledge easily. In order to upgrade the knowledge, the researchers organized learning and sharing forum, participatory sub-group conferences and folk forums. Participants were members of Woman Local Weaving Group, local leaders, community development officers, local authorities, local government agents and youths from Ban Phone Chan School. It took 2 months for this activity.

Activity IV: In order to manage the traditional wisdom and to add value to the wisdom, the researchers organized some sub-group conferences by using the knowledge from Activity III to develop the weaving of Tai-so. Members of Woman Local Weaving Group participated this activity. It took 1 month for this activity. There were 2 sub-activities for this process. The 2 sub-activities are as follows:

Sub-activity 4.1: Sub-group conference was held to brainstorm ideas for products development and value-added products.

Sub-activity 4.1: The researchers concluded interpreted and analyzed obtained knowledge.

Activity V: The researchers wrote the report. It took 2 months for this activity.

4. METHODOLOGY

1 The researchers employed Desk Study to review some literature.

2. The researchers employed Group Interview to study community context.
3. The researchers employed Focus Group Interview to study weaving traditional wisdom and processes of weaving traditional wisdom transfer.
4. In-depth Interview was employed to study the people's view on applying the wisdom to develop cultural goods.
5. The researchers employed Observation to collect community social structure and environment.

5. DATA COLLECTION

The researchers employed In-depth Interview, Focus Group Interview, organizing learning and sharing forums, Observation, interpretation from learned activities under members of Woman Local Weaving Group, local leaders, local authorities, local government agents, Rajabhat University Cultural Center, Nakhon Phanom Cultural Office, Nakhon Phanom Cultural Council, Phone Sawan District Office and Phone Chan School cooperation.

6. DATA ANALYSIS

Data analysis, descriptive analysis, was done along with data collection.

Results and Findings

6.1. Findings on cultural context on weaving of Tai-so's community, Phone Chan Sub-district

1) Tai-so people used their area to plant rice and to build their shelters instead of the area for their cotton, Indian mulberry leave, and true indigo tree. Owing to population expansion, they needed more area for rice as well as dwelling area so they lessened the area for cotton, Indian mulberry tree.

The findings indicated that weaving culture of Tai-so's community, Phone Chan Sub-district was unavoidably affected. In the past 40 years, the area for their cotton, Indian mulberry tree and true indigo tree was gradually lessened. This affected cotton thread producing process. The process and "Long Khuang Khen Fai" tradition were faded away from Tai-so's community.

2) In the past 30 years, the government had developed roads between Kusumarn District and Tha U-tane District. This facilitated traders to bring clothes, synthetic fibers, cotton thread from factories and chemical dye from factory to sell in Tai-so's community more.

From the above findings, this cultural phenomenon directly affected weaving culture of Tai-so's community because the people had a new alternative, clothes, synthetic fibers, cotton thread from factories. The alternative was not only convenient but also responsive. Because of more convenient weaving, the people could increase their weaving which could respond Tai-so clothing demand effectively.

The above phenomena effected and lessened local wisdom on weaving culture transfer of Tai-so people at Phone Chan Sub-district.

6.2. Findings on traditional wisdom on weaving of Tai-so's community, Phone Chan Sub-district

6.2.1 There were three types of Tai-so's woven cloth

6.2.1.1 Daily life cotton cloth was plain- woven cloth with desired color dying. It is a quick and durable product. Here are some products.

1) "Lagol" or pillow

There are two types of Lagols. The first is "Lagol Poonjae" or a handmade rectangular pillow which was made from hand-woven cloth with various color stripes. The pillow was a "Lai Khid" pattern pillow. The people used "Lagol Poonjae" for sleeping. The second is "Lagol Paijae" or a handmade triangular pillow which was made from hand-woven cloth with various color stripes. It was use for sitting.

2) "Yer" or "Pha Toom" or "Pha Hom"

There were many imaginative patterns. Three woven cloth was sewed together. Edges were hemmed. The people use this cloth to cover their body on Tai-so's festivals.

3) Prejanuan (bed sheet)

The people use this cloth to cover their bed. There were many imaginative patterns. Three woven cloth was sewed together. Edges were hemmed.

5.2.1.2 Woven cloth for garments

1) Jagadmee (Pha Sin Mud Mee)

The cloth was woven by Tai-so women.

2) Prei Kaeb (Pha Yok Dok)

This embossed pattern cloth was woven from cotton or silk. It might be embroidered with golden thread then cut and used for other purposes.

3) Pre Ta Long (Pha Khao Ma)

The cloth was a daily general purpose for Tai-so people. They were colored woven cloth. The color might be blue and white, red and white, green and white, black and white etc. The cloth can be used as a skirt, a belt, a hat.

4) Pre Jub Kree Arm (Pha Fai Yom Kram)

This cotton cloth was dyed indigo. The hand woven cloth was use for Pha Sin (skirt) or a pair of trousers. It was ideal for sweat blotting.

6.2.1.3 Woven cloth for ceremony and VIP's souvenirs

1) Prei Kaeb (Pha Keb)

This magnificently woven under spiritual belief might have some ideas from natural and supernatural imagination. There were so many patterns such as Phrya Nak (holy serpent), elephants, horses, flowers etc. It was woven by a highly skilled and high inspiration weaver. Tai-so women use this cloth to cover their shoulders. Every Tai-so woman had this cloth and generally wore this cloth on their clothes in "Saeng Sa Nam" rite, grandfather or grandmother funeral rite. It could be used as a souvenir for VIP's.

2) La Gol (Mhon Kid)

The cloth was used for making a pillow which had patterned with natural and supernatural imagination. It was use a pillow for paying respect (Krab Wai) on "Saeng Sa Nam" rite.

6.2.2 Cloth pattern at Tai-so Community at Phone Chan Sub-district

It was found that Tai-so's weaving handicrafts told their belief, faith, love and history of the way of life. The cloth was woven under spiritual belief. In addition, the cloth was neat pattern design, color-dyed, selected material for weaving and process of the weaving. There were three patterns for their cloth. They are:

1) Pha Mudmee pattern

In the past, Tai-so women wove indigo-dyed Pha Mudmee cloth with animal picture such as nagas (holy serpents), Lai Krua Ob (vine pattern), Lai Krua Bun (vine pattern). It is for household use. Later they used synthetic fiber instead of former indigo-dyed material. This made weaving quicker and easier.

2) Pha Yok Dok pattern

In the past Tai-so women wove embossed pattern on their colorful cloth. This high contrast color cloth was typical of their work. The cloth went well with "Teen Sin Mud Mee" or a cloth band for a cloth rim. The band had dark-toned color. They sew the band, "Teen Sin Mud Mee", on the rim of the cloth.

3) Pha Keb pattern

In the past, Tai-so women used Pha Keb Mue to decorate on their garment such as cover-shouldered cloth, shawl, cover on grandfather or grandmother's coffin, Mon Kid pillow etc. This magnificently woven under spiritual belief might have some ideas from natural and supernatural imagination. There were so many

patterns such as Phrya Nak (holy serpent), elephants, horses, flowers etc.

6.2.3 Hand-woven cloth at Tai-so Community at Phone Chan Sub-district

There were four kinds and processes.

6.2.3.1 Basic woven cloth

It was a basic woven cloth. The people used cotton fiber, silk fiber or synthetic fibers for woven material. The cloth was ideal for shirt, blouse, pillow, sarong, loin cloth, mattress or household decoration. The people sew the cloth band on the upper rim of a skirt. It was Tai-so favorite cloth.

6.2.3.2 Prei Mee (Pha Mud Mee)

It was use for sewing Tai-so's daily garments. In addition, they wore the garments on their ceremonies and rites. Mud Mee cloth will be used to sew the upper cloth band (Hua Sin) and the lower cloth band (Teen Sin). This typical skirt was called "Prei Mee" or "Pha Sin Mee". There were two types of "Pha Sin Mee". The first one was traditional "Pha Sin Mee". Its patterns described on Tai-so's belief. The second one was modified "Pha Sin Mee" or "Pha Sin Mee Pra Yuk". The cloth was modified from Pha Sin Mee. New patterns might be added to typical patterns.

6.2.3.3 Pri Ya Ok Pier (Pha Yok Dok)

In the past Tai-so women wove embossed pattern on their colorful cloth. The cloth will be used as "Teen Sin Mud Mee" or a cloth band for a cloth rim. Most of Pha Yok Dok has a primary color. The people sew the band, "Teen Sin Mud Mee", on the rim of the dark plain-colored cloth. This made a high contrast color.

6.2.3.4 Prei Kaeb (Pha Keb)

In the past, Tai-so women used Pha Keb to decorate their garments such such as shawl, cover-shouldered cloth, cover on grandfather or grandmother's coffin, Mon Kid pillow etc. This hand-woven cloth was woven under spiritual belief. The weaver might put some ideas from natural and supernatural imagination on the cloth via weaving. There were so many patterns such as Phrya Nak (holy serpent), elephants, horses, flowers etc. It was generally worn in "Saeng Sa Nam" rite, grandfather or grandmother funeral rite. It could be used as a souvenir for visitors. Men may use at as a belt but women may use it as cover-shouldered cloth.

6.3 Findings on** data **of traditional wisdom on weaving of Tai-so's community, Phone Chan Sub-district

6.3.1 Tai-so's weaving situation

In the former time, Tai-so women participated actively in "Long Khuang Khen Fai" Tradition in January every year. It held on a full-moon day so as to get light for doing cotton activity at a yard or an outdoor space of the village. Tai-so men had a good chance to observe Tai-so women's cotton processing skills. This was essential information for choosing their lovers. Young men and women sat together. Kaen and Pin which were their typical musical instruments were used to entertain the activity. Men wooed women by using "Phaya" or "folk poem".

Although the tradition was lost from Tai-so's community for 40 years, Tai-so people at Phone Chan Sub-district continued their weaving traditional wisdom. There are 120 looms in the community. Ninety percent of the people weave their own cloth. Some families sell their surplus to other communities. Their weaving is homemade. At the present time, Tai-so women buy synthetic fiber from 2 shops in their community. They are Ratchanee Pothiya's and Hug Laoluang's. The two shops buy the fiber from Hung Teng's and Kham Pramong's in Sakon Nakhon which buy the fiber from Taweechai's at Khao Wong District, Kalasin. Taweechai's shop is a main cotton fiber distributor for the Northeastern and Lao PDR.

Now days there are two women who are the assets for weaving in the community. They are Mrs. Phrom Kham Pratet, 92 years old, and Mrs. Sor Kutchana, 74 years old. They use cotton which was planted by the young to weave Tai-so's cotton cloth.

In 1995, Mrs. Vanida Ratchamanee from Village No.2 and Mrs.Rasamee Ratchamanee from Village No.10 are leaders of Tai-so's Housewife Goup. The group was settled to cloth products such as garments, Tai-so's clothing, pillow slips, tissue cover and bags. The group has 40 members.

6.3.2 Raw materials

6.3.2.1 Cotton

The people plant rice and white cotton annually on May. Cotton can get full rain-fed during June to August and in November or December, it will mature enough for harvesting. The people harvested cotton after they had harvested their rice. Cotton bolls then come to spinning and weaving.

6.3.2.2 Silk

In the past Tai-so community had their area for planting mulberry leave. The leaves are food for silkworms. They raise Thai silkworms which have dull yellow, small size, pointed head and tail. The worms give thick and durable fiber. At present the people plant mulberry tree at their backyard.

6.3.2.3 Synthetic fiber

Tai-so women tend to use synthetic fiber. They replaced cotton fiber with Torei synthetic fiber because it is convenient raw material for weaving. They buy the fiber from Ratchanee Pothiya's and Hug Laoluang's.

6.3.3 Tools for cotton fiber producing

6.3.3.1 In the process of cotton fiber producing of Tai-so women, there are five components for a cotton fiber producing tool. They are "Eiw", "La", "Kan Deed Fai" and "Mai Pia".

6.3.4 Process of cotton fiber producing

After harvesting the cotton bolls, the bolls were brought to the process skillfully. The process is:

6.3.4.1 Eiw A Pai (Boll extracting)

After harvesting the cotton, the people use their traditional cotton boll extracting tool, Kroeng Eiw Fai, to extract the bolls. The seeds are removed by using a wooden Eiw, where the cotton is fed between two rollers by hand cranking. The seeds are too large to pass between the rollers and drop or are picked off. Seedless cotton collects in the pick basket

6.3.4.2 Deed A Pai (Karn Deed Fai)

A bow-shaped tool, which is made from bamboo with a cord binding on each end, is made to produce cotton fibers. This gives consistent fiber. It is a ginning cotton process.

6.3.4.3A Loi A Pai (Karn Lor Fai)

Karn Lor Fai is the process to make tubular cotton fiber by using a tool, Mai Lor. Mai Lor, a chopstick-liked with a wood plank, is used to roll the cotton boll. The ginned cotton then is roll on Mai Lor on a wooden plank by using hands. This makes tubular fiber around the Mai Lor. Pull the Mai Lor out and bring this tubular fiber for the next process.

6.3.4.4 Tee A Pai (Karn Khen Fai)

The people use "La" which is a handmade wooden tool to make cotton thread. La with a cotton thread belt is spun by hand. "La" Spinning means "Lek Nai" spinning and spinning cotton thread. The thread coiled around "Lek Nai". The obtained thread, "Jai", was collected separately. Many Jais were bundle together to make "Poi". This process is called "Phai Khen Mue".

6.3.4.5 Thread processing

The process is called "Kha Fai". In order to toughen and smooth the thread, they boil rice into thin soup. Put "Jai Fai" in to a large pot with rice thin soup in it. Boil the fibers. Let them cool. Massage the fiber in the pot with hands. Dry the fiber on a bamboo rail. Comb the fiber.

6.3.5 Silk fiber producing

Like other silk processing in the Northeast, Tai so plant mulberry leaves for the silkworms, raising the worms and bringing fiber from cocoons.

6.3.5.1 Mulberry Planting

Tai-so plant their mulberry at their garden and unused area in their rice field. It is a local variety mulberry with large leaves and fit for the silkworm food.

6.3.5.2 Silkworm Raising

Tai-so at Phone Chan Sub-district plant mulberry and raise silkworms at the same time. It is an inherited way of life like other tribes in the Northeast. Life cycle of silkworm is incubation stage, larva stage, pupa stage and imago stage. In pupa stage, the worms give silk fibers which Tai-so use it to weave their precious silk cloth.

6.3.6 Dying

The process begins after they have prepared cotton and silk fibers already. They get the dyes from natural, plants from their farm. It is a safe and simple process which gives mild and gentle color. There are two dying process. Cold dying process is the process which the people use indigo plant to make indigo color and "Ma Gruea" (Diospyros mollis Griff) to make black color. The second one is hot dying process. Tai-so uses some plant barks. "Pradoo" (Pterocarpus indicus) bark is used for red color. For yellow color, they use "Lin Fa" or "Pe Ka" (Oroxylum indicum) and "Intanin" (Lagerstroemia calyculeta Kurz) and "Kra Done" (Careya sphaerica Roxb) are used for making black color dyes.

6.3.7 Weaving Equipment

Tai-so uses the same weaving equipment as other tribes in the Northeast. They bought some parts of the equipment from Thai-Lao in the Northeast. Weaving equipment is essential for producing garments which is their main value-added product.

6.3.8 Cloth Pattern Design Process

For Tai-so, weaving cloth means telling legend, faith, belief, love and some important events in their tribe. It is Tai-so's cultural identity. The process of cloth producing is well-prepared, neat pattern-designed, neat color-dyed and selected-material. The cloth is magnificently woven under spiritual belief which may have some ideas from natural and supernatural imagination.

6.3.9 Weaving Process

Tai-so at Phone Chan Sub-district has inherited their weaving process. There are 4 types of their cloth: Basic Pattern Cloth, Mud Mee Cloth, Pha Yok Dok Cloth and Pha Keb Cloth. They are differentiated traditional wisdom on weaving.

7. FINDINGS ON WEAVING TRADITIONAL WISDOM TRANSFER

7.1.1 Weaving Traditional Wisdom Transfer within Family

Mothers play important role on Tai-so's weaving traditional wisdom transfer. They transfer to daughters, nieces and nieces-in-law respectively. The successors have learnt how prepare the fibers and weaving process since they were about 14 years old. It is direct experience learning. The lesson begins by weaving basic weaving cloth such as basic stripes cloth, Pha Khao Ma. The mothers will evaluate their successors' skills and inspiration. If the successors are skillful, they will be assigned for fabulous weaving such as silk cloth, sarong.

7.1.2 Weaving Traditional Wisdom Transfer within Community

It is a highly skilled weaving for Pha Mud Mee, Pha Yok Dok and Pha Thor Si Khao (Poon Kao). Craftsmanship depends upon successors' inspiration and process of the transfer.

7.1.3 Weaving Traditional Wisdom Transfer for Outer Community

The wisdom transfer comes with the people's migration, intermarriage. In addition the people from tribes may exchange their presents such as Pha Keb, Pha Yok Dok,

silk cloth, Pha Mud mee and Pha Thor Si Khao (Poon Kao) on the intermarriage ceremony. This includes cloth exchange among Tai-so from other communities during their festivals.

7.2 Forms of Tai-so's Weaving Traditional Wisdom Transfer

7.2.1 One by One

This form of transfer is employed within family and relatives. The wisdom is the family's asset. They had promised their ancestors to keep the secret of the wisdom so it is not easy to tell the wisdom to other people outside the family.

7.2.2 Group

The group transfer method comes from one by one method after the weaving experts being honored by the community. Successors which are the experts' younger relatives transfer the wisdom to their family members, and then the wisdom diffuses to distant relations in community. This method is rarer than the one by one method.

8. BUILDING CONSERVATIVE CONSCIOUS ON TAI-SO'S WEAVING CULTURE

8.1 Building Conservative Conscious in Family Level

Mothers tell their children stories about Tai-so's weaving traditional wisdom at Phone Chan Sub-district. This may raise the children concern on their ancestors' wisdom. The ancestors expected their descendants to keep and transfer the wisdom to descended family. Grandparents gave their fabulous cloth to their descendants to cover their coffins so the cloth will be well-kept or used in their important rites. The cloth is the prototype pattern and the descendants can copy it. The descendants can develop the cloth pattern and ask the weaving experts for recommendations.

The above manner helps Tai-so's at Phone Chan Sub-district build conservative conscious on their weaving.

8.2 Building Conservative Conscious in Tai-so's Community at Phone Chan Sub-district

In olden times, Tai-so's people at Phone Chan Sub-district could sustain their way of life because they depend on each other. In that time, there were natural disasters, flooding, drought, epidemic, robbery in the community. This made the people gather. They believed in spirits and worshipped them. It was their belief that spirits unified them. The belief diffused across the community so they were cultural relatives.

From the above postulates, Tai-so's people at Phone Chan Sub-district build conservative conscious on weaving traditional wisdom by placing their belief on their cloth. The pattern shows their spirit worshipping and supernatural powers such as Phraya Nak (Naka). The beliefs have implanted in Tai-so's weaving imagination. The cloth is magnificently woven by experts under spiritual belief which can be transferred to their descendants' conscious.

8.3 Building Conservative Conscious in Tai-so's Community at Phone Chan Sub-district via Religious Institute

Wat Phone Sai has kept some cloth which was used in rites. The people wove cloth and gave it to monks on festivals. The monks' garments were Pha Arb Nam Phon, Pha Biang, Pha Sabong, Pha Thung, triangular pillow and other cloth gadgets. The people can use these as their weaving prototypes. The people believe that if they give fabulous garments for monks, they will wear fabulous garments in their next life. Tai-so's people at Phone Chan Sub-district indoctrinate this belief.

8.4 Building Conservative Conscious via Tai-so's Weaving Experts

At Phone Chan Sub-district, like other communities in the Northeast, the people can learn traditional local knowledge from local experts by presenting themselves to the experts. After presenting their intention to learn the local wisdom, the expert generally admits his apprentice. The apprentice pays respect to the expert. This subconscious manner helps the apprentice to love their transferred knowledge which was given by the expert. The admired expert willingly teaches and reinforces the apprentice. The apprentices will finally gain their skills. Some apprentices may set a rite, "Bai Sri Soo Kwan", to pay respect for their expert.

8.5 Building Conservative Conscious via schools

Ban Phone Chan School in Tai-so's community at Phone Chan Sub-district has taught Tai-so weaving technique since B.E.2545. There are two ways of the teaching-integrated the knowledge with students' social study and activity in Weaving Club. The school raises students' concern for weaving local wisdom and allows teachers and students to wear Tai-so's garment on Tuesdays.

9. WAYS TO USE TAI-SO WEAVING TECHNIQUE FOR PRODUCING CULTURAL PRODUCTS

Under Tai-so's community active participation, this manner builds databases on their traditional wisdom. There are some constructive ideas to produce Tai-so's cultural products. In order to add some value for the product, they ran three activities.

Activity 1: survey Tai-so's weaving products from local wisdom databases in order to learn their identity (pattern, color, shape, type etc.)

Results: It was found that Prei Keb (Pha Keb) is the most important product because it was woven by expert under their supernatural belief and high inspiration.

The second rank is Pha Yok Dok which was also woven by expert under their supernatural belief and high inspiration. Weaving process for Pha Yok Dok is different from Pha Keb. Pha Yok Dok is rich in patterns and color so Tai-so women love to sew Pha Yok Dok on Pha Tum (Pha Hom or blanket) or on Teen Sin Mud Mee.

The third rank is Pha Mud Mee which has its pattern

like other Pha Mud Mee from the Northeast community but there is some difference. Pha Mud Mee from Phone Chan Sub-district has its identity. It may have some icons such as Phraya Nak (Naga), Lai Karb, Lai Khor.

The fourth rank is Pha Tor Si Khao which has its pattern like other Pha Tor Si Khao from the Northeast community but there is some difference. Tai-so women love to weave Pha Si Khao (Ta Kor) for their blankets and sheets. The cloth has more complex pattern than basic "Lai Khad" cloth.

The fifth rank is basic "Pha Tor Lai Khad" which has its pattern and form like other basic color cloth from the Northeast community

Activity 2: survey existing Tai-so's weaving products such as garment, household products in the community. The information will be use for designing and producing Tai-so's cultural products.

Results: From the survey, there are two categories to consider.

1. Garment

1) Cotton cloth

It was found that Tai-so people love to wear indigo-dyed shirts and cotton ready-made clothes.

2) Pha Sin Mud Mee (Mud Mee skirt)

Tai-so women love to wear indigo-dyed Pha Sin Mud Mees and Pha Sin Mud Mees which were woven from synthetic fibers.

3) Pha Sin Lai Khad Phuen Than

Tai-so women also love to wear indigo-dyed Pha Sin Lai Khads and Pha Sin Lai Khads which were woven from synthetic fibers.

4) Sarong

Tai-so man usually wears Sarong when he goes out, meets relatives and friends. Tai-so woman sometimes wears Sarong instead of Pha Sin to attend Saeng Sa Nam Rite (Long Sa Nam).

5) Pha Khao Ma

Tai-so man wears Pha Khao Ma for his daily wear in his house.

6) Pha Biang or Pha Klum Lai

Tai-so woman likes wearing Pha Keb over her shoulder. The cloth is called Pha Biang. She wears Pha Biang to attend Saeng Sa Nam Rite. Pha Biang is ideal for a souvenir for VIPs.

7) Cotton trousers

Tai-so man love to wear indigo-dyed cotton trousers and trousers which were woven from synthetic fibers.

2. Household products

1) Pha Tum (Pha Hom or blanket)

Tai-so people love to cover themselves with Pha Tum to join Tai-so's festivals in winter.

2) Pha Poo Non (sheet)

Tai-so people use Pha Yok Dok to make their sheets. They also made seams for the cloth. Before sleeping, they put the sheet on their wooden floor of their houses.

3) Mon or Mon Khid

It is a rectangular pillow which was decorated with Khid pattern.

4) Mattress

Tai-so people use Lai Khad Phuen Than cloth to make their mattresses. They sleep on the mattresses which were stuffed with kapok.

5) Yarm

"Yarm" or a bag is made of cloth with a shoulder strap. Tai-so man use Yarm for carrying his effects when he goes to his farm.

Activity 3: Ideas for producing Tai-so's cloth products. In order to conserve Tai-so's identity and designing the products, results from Activity 1 and 2 are used.

Results: Members from Tai-so's Local Cloth Weaving Group have a brainstorm for product development and producing. Here are some outputs from the brainstorming.

1. Mon Khid can be decorated with Pha Keb which has vivid- colored Khid pattern.
2. Pillow case can be made from Lai Khad Phuen Than cloth such as Pha Khao Ma.
3. Backrest sheet can be made from Lai Khad Phuen Than cloth such as Pha Khao Ma.
4. Using Pha Yok Dok and Pha Keb to decorate shirts and blouses instead of lace can add value for garments.
5. Bags with various styles can be made from Pha Khao Ma.
6. Pha Keb can be used for home decoration.
7. Making a tissue box from Pha Khao Ma and Pha Mud Mee
8. Indigo-dyed cotton cloth for children garments can be decorated with Pha Yok Dok.

10. RESEARCH RECOMMENDATION

1. Community participation from every social sector for Tai-so weaving traditional wisdom conservation is crucial. Local leader changing should not affect the conservation. For sustainable culture, the traditional wisdom should be diffused among youths at Phone Chan Sub-district community.
2. Quality control on Tai-so textile, conserving textile uniqueness and effective price control on the products creates quality and price of the products equilibrium.

11. RECOMMENDATION FOR FURTHER STUDIES

1. A study on Tai-so textile standard development
2. Knowledge management on organic cotton planting by Tai-so traditional wisdom
3. Develop Tai-so weaving traditional wisdom to a universal wisdom

12. RESULT IMPLEMENTATION

1. A body of knowledge on Tai-so weaving traditional wisdom transfer, which is easily accessible by the people, should be set as a local knowledge curriculum.
2. Tai-so should be developed their potential on weaving traditional wisdom transfer to their youths.
3. From Tai-so weaving traditional wisdom, it is possible to use the body of knowledge to produce various cultural goods and to add value on community.
4. From 3. projects on producing various cultural goods and adding value on community should be accommodated on community plans vertically.
5. Tai-so cultural of Phone Sawan District, Nakhon Phanom, should be diffused and conserved by combining it to O-TOP cultural goods producing of the Thai government's policy.

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Current Trends of Urban Development in Yangon City and Its Implications on The Environment

San San Moe

Abstract— *Yangon, the former capital city of Myanmar and its main gate-way to the world, has been considered as the most suitable location for the majority of non-agricultural activities in Myanmar in the last decade. In the past few years, Yangon has through a phase of rapid constructional development. This development has resulted in the growth of Yangon over its previous administrative boundaries, and in tremendous changes of land use. The land use changes led to more and more environmental problems and to shortages in the provision with infrastructure. As the negative effects of spontaneous land use pattern such as insufficient land use and damage of the natural resources along with the urban environmental problems of the mega-size urban area hardly can be overcome after arising, they are thus to be minimized in advance by a for sighted concept of efficient framework for land utilization pattern of future urban expansion in the Yangon City. This city has higher population density due to more accessible and positive economic situations than other areas. Due to the increase in population and urban-expansion policy of the government, there were significant environmental changes, especially in land use during the period from 1988 to 2005.*

Keywords— **Environmental problems, land use changes, population growth, urban development, Yangon.**

1. INTRODUCTION

On a global average, urban areas generate 60 percent of a nation's gross national product. If properly managed, urban settlement can develop a country's capacity to sustain productivity, improve the living conditions of residents and manage natural resources in a sustainable way [1].

Compared to many other countries in the region, Myanmar still has a predominantly rural population of around 73 % and 27 % of the total population of 52 million lives in urban areas [2]. Yangon population is around 4 million in 2004. This means 30 % of total Myanmar's urban population and Yangon is population wise about 4 times larger than Mandalay, second largest city of Myanmar. The population of all other urban centers of states and divisions in Myanmar range from twenty thousand to three hundred thousand [3].

Yangon city served 8 % of the total union population. With the present population growth rate of 3.4%, Yangon populations will reach around 10 millions in year 2030 [4].

Yangon provides the location for half the industrial capacity, for the largest financial and marketing center, and is the largest provider of important services in education, health, culture, tourism, research and development. Although the legislation of border trade and liberalization of the economy are generating rapid growth in other centers, Yangon remains as the pole of national economy. It is thus crucial for the economic development of the country, and any pattern of economic growth is likely to see the disproportionate growth of the population of the metropolis.

Over-all objective of this research is to investigate on the urban development of Yangon in different phases and to find out the changing trends of urban development in Yangon. This paper highlights the points that any form of physical and cultural change should take into consideration the social, cultural continuity and identity of Yangon inhabitants. The methodological approach is based on the both of qualitative and quantitative method. This paper presents current urban developments carried out in different phases, 1989-1993, 1994-1998 and 1999-2002.

It highlights the housing reforms initiated by Department of Human Settlement and Housing Development (DHSHD). Private sector participation is elaborated and it is highlights that are recent achievements in carrying out Huts to Apartment Project. It also presents the implications caused by population growth in Yangon and recent urban developments. Issues such as solid waste management, water supply and sanitation and transportation become major problem areas. It concludes by stating the needs for structure plan, planning legislation, institutional framework and capacity building.

Yangon City is the former capital of Myanmar, East longitude 96° 13' and north latitude 16° 45' run through on Yangon City. It is located at the confluence of Yangon and Bago rivers. It is situated on a flat low lying land at the southern end of Bago mountain range. The topography is a somewhat higher in the north and lower in the south, rivers such as Hlaing River are found on the west, Ngamoeyeik Creek on the east, Yangon River on the south and Pazundaung Creek on the south-east.

The presence of these rivers and the nearness to the sea pose a challenge in keeping the city free of flooding. There are also lakes such as Hlawga Lake, Inya Lake and Kan Daw Gyi Lake.

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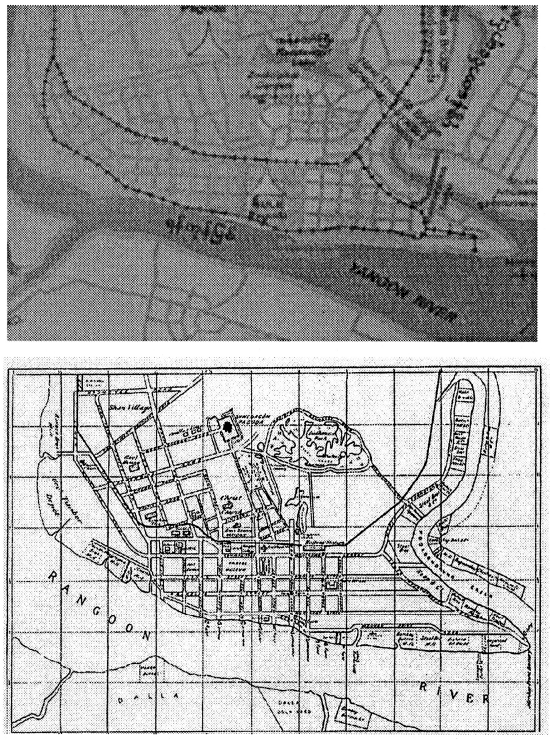

Fig. 1. Yangon between 1920s and 1980s.

Yangon is a port city, also has the Yangon International Airport and the central business area. Most of government organizations, private firms, universities and industries are concentrated in the Yangon City. It is organized by central business district (CBD), inner urban ring (IUR), outer ring (OR), south of CBD (SCBD), older suburb (OSU), northern suburb (NSU), and new suburb (NS).

It has 33 townships including CBD, which is formed with 7 townships and located along the Yangon River. International port and harbors are located in CBD area.

2. RESEARCH METHODOLOGY

There are two data sources, primary and secondary data. Primary data were collected by observation method (field visits) and secondary data were collected from Yangon City Development committee (YCDC) and Department of Human Settlement and Housing Development. Additional data were collected from published and unpublished reports, research studies and articles by different researchers, line agencies and non-governmental organizations.

Collected information using primary and secondary data collection methods were used in order to analyze qualitatively and quantitatively. Information regarding land use changes and existing urban expansion were analyzed by using charts: such as excels package, tables, maps and photographs.

The research is divided into four sections. The first section presents the current situation of land-use planning in Yangon City practicing in real recent development plan of Yangon district. The second section investigates possible high and low priority of central place function in Yangon city. The third section evaluates population growth, population distribution and projected population in Year 2020. Lastly, the fourth section covers some appropriate trends of urban development and its future prospect to improve the current situation by suggesting and producing the gridlines for strategic Master Plan.

3. YANGON CITY AREA DEVELOPMENT

Yangon City was founded in 1755 by Myanmar king Alaungphaya and replanned as the capital city of lower Myanmar in 1852 by the British colonial for 50,000 inhabitants. The area of the city at that time was about 25.9 square kilometer. In 1940, the city covered an area of 98.5 square kilometer with a population of 450,000. Since then the city has grown to 3.5 million populations with 593 square kilometer in 1997.

Due to the development of new satellite towns since 1987, the northwards sprawl of the city has changed to a cross pattern having an east-west axis and a north -south axis. The average population density of the city at present is 30 persons per hector, which is very low compared to other neighboring countries' capital city [5].

Large-scale urban development activities have been carried out in Yangon since 1989. Mixed-use developments have come to be undertaken in the central business district and in the areas vacated by large-scale squatter relocations. Isolated developments of great bulk are beginning to appear in the city. There are office buildings, hotels and housing. These three elements generally form the skyline of the intensively built up city.

The city is divided into 33 townships, which may be grouped into three areas with different socio-economic settings as follows.

(1) The Central Business District (CBD) with most of commercial and administrative activities;

(2) The Sub-urban townships with commercial and industry establishments

(3) New towns which are mostly residential and industry establishments

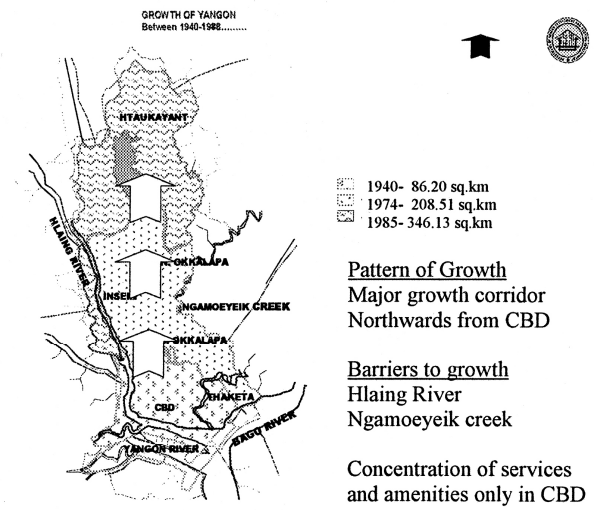

Fig. 2. Planned Urban Expansion after 1988.

4. YANGON CITY CHARACTERISTICS

Yangon City, the former capital and premier city of Myanmar with a current population of 4.35 million and an area of 795 sq-km is administrative by the Yangon City Development Committee (YCDC). The primacy of Yangon is expected to remain as it is presently the most dominant city, accounting for more than 52.74 percent of the total urban population in the Union. Mandalay, the second largest city is only a quarter of its size (1057600 people) [3].

The primacy of Yangon city is an important aspect in the overall planning of its future growth. The impact of a strong and sustained growth and structural changes will be strong on the city, since the dynamics of such growth is bound to enhance its primacy. For purpose of analysis, the Central Business District (CBD) will include the seven townships which are located in the downtown area and have high development intensity. These include (7) townships of Botataung, Kyauktada, Lanmadaw, Latha, Pabedan, Pazaungdaung, and Seikkan with land area of about 8 sq-km. The population of CBD was 245,530 in 1983 and increased to 321,922 in 2003.

Within the Yangon City (YCDC area) the 33 townships also demonstrate varying primacy index (PI) over the past years and is expected to improve during the planned period from 0.40 to 0.21 (1983-2020) with more balanced and equitable growth in the city region. This could be partly attributed to the resettlement programme of relocating squatters to the suburban areas and the new towns developed by government. The projected population of the CBD is expected to increase slightly to 311,751 (2010) and 357,709 (2020). The Primary Index (PI) of the CBD however, is expected to fall further from 0.29 to 0.21 indicating that future population growth will be directed to the suburban areas as a result of the CBD being develop for commercial and office uses.

Table 1. Primacy Index for Yangon City (1983-2020)

Sr. No.	Year	Primacy Index
1	1983	0.40
2	1993	0.37
3	2003	0.32
4	2010	0.29
5	2020	0.21

The present town ship character can be categorised in to Central Business District, Outer, Older Suburbs, Suburbs, New Towns and countryside. Central Place Function (CPF) of these townships have also been analysed based on their economic activities, social services and facilities, transport and communication services and facilities, recreational activities, community organization, protective services, infrastructure and maintenance facilities and personal services. (See table - 2)

Table (2) shows the benefits of central place functions based on the survey in the categorized zonal area of Yangon. In terms of the priority by benefits of CPF, Inner Urban Ring and Central Business District obtained high level benefits while other zonal areas are at moderate level in Yangon. Only one zone of South of CBD area is low benefit from CPF. But these townships are located at very near CBD.

Table 2. Central Place Function by Zone

Area	Central Place Functions by %								Priority
	I	II	III	IV	V	VI	VII	VIII	
CBD	26.0	22.8	26.6	14.5	36.0	19.6	21.2	27.5	H
IUR	23.5	25.5	22.0	29.0	22.9	23.3	28.0	24.0	H
OR	11.5	12.4	12.0	15.7	8.0	13.7	14.0	16.0	M
SCBD	2.0	4.8	4.1	4.3	1.7	2.6	2.7	1.8	VL
OSU	10.5	9.3	9.1	12.6	9.9	9.7	11.2	7.7	M
NSU	9.5	8.6	9.9	10.4	8.3	12	8.9	8.3	M
NS	17.0	16.6	16.3	13.5	13.2	19	14	14.7	M
Total	100	100	100	100	100	100	100	100	M

Note: CBD=Central Business District, IUR=Inner Urban Ring
OR=Outer Ring, SCBD=South of CBD, OSU=Older Suburb
NSU=Northern Suburb, NS=New Suburbs
VH=Very High, H=High, M=Moderate, L=Low, VL = Very Low
I=Economic Activities, II=Social Services and Facilities
III=Transport and Communications Services and Facilities
IV=Recreational Activities, V=Community Organization
VI=Protective Services, VII=Infrastructure and Maintenance Facilities, VIII=Personal Services

5. POPULATION GROWTH AND DISTRIBUTION OF YANGON CITY

The total population of Yangon City is estimated to be about 4.35 million in 2005, with an average growth rate of 2.5 percent during 1983-2005 periods. The rate of population growth increased from 2.11 percent during the 1983-1993 periods to 2.87 percent during 1993-2005 periods (Table-3).

The population growth of Yangon City was higher that Yangon Division is 2.2 percent and Union of Myanmar is 2.0 percent. The higher growth of Yangon City population was attributed to migration from rural areas of Yangon Division (Outside City) and from other states.

Table 3. Population of Yangon City and Yangon Division, 1983-2005

Area	Population (in million)			AAGR (%)	
	1983	1993	2005	1983-1993	1993-2005
I	2. 513	3. 097	4. 350	2.11	2.87
II	1. 452	1. 870	2. 108	2.56	1.00
III	3. 966	4. 967	6. 459	2.28	2.21
IV	35. 308	43. 116	54. 681	2.02	2.00

Note : AAGR = Average Annual Growth Rate

I = Yangon City, II= Outside City, III= Yangon Division, IV= Myanmar

Source: Adapted from unpublished statistics,

Department of Population, Union of Myanmar

The distribution of Yangon City population according to townships is shown in appendix. Population was largely concentrated in several townships such as Insein, Thingangyun, Tharkayta, North Okklapa, South Okklapa, Hlaing, Mayangone and Mingalardon. (See table-4).

Population growth of the townships varies. The growth of Inner City Area has low growth rate less than 1 percent per annum. On the other hand the townships located at the fringes towards north-west and eastern part of Yangon City has experienced rapid increased in population with growth rate of more than four percent. These are the areas where future direction of growth shall be expected. (See table-4)

The population is projected to rise to about 6.8 million by 2020, with an average growth rate of 3 percent. The increase is largely due to net in-migration to the city of about 140,000 per annum. The rate of increase due to birth is about 22,000 per annum.

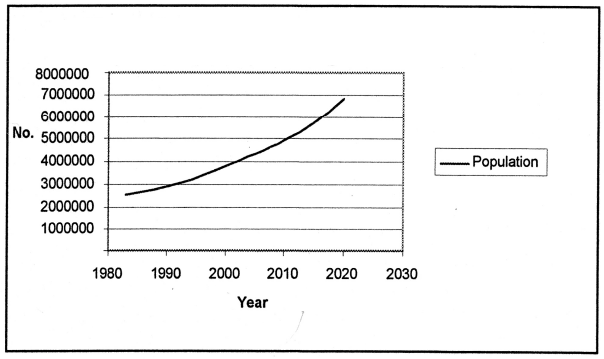

Fig. 3. Projected population of Yangon, 2010-2020.

The population of the townships located at the eastern and western fringes of the cities is expected to grow more than four percent per annum while the population of older townships located in and around the inner city is projected to increase much slower (less than 2.0 percent). These inner city townships have limited area for future expansion and the density is already high.

6. CURRENT TRENDS OF URBAN DEVELOPMENT IN YANGON

Two main bodies, YCDC and DHSHD manage urban land. YCDC is responsible for administering private land whereas DHSHD caters to the need of government land. The committee charged by the Prime Minister decides all change of use of urban land in Yangon City.

The Housing Delivery System in Yangon can mainly be divided into Two Main Sectors of Private and Public sector. The Housing Delivery System in Myanmar is predominantly private. The DHSHD provides rental housing for government employees in several major administrative towns. As Yangon population accounts to 30% of total urban population, the housing delivery system of Yangon represents a significant portion of the urban housing delivery system in Myanmar.

Initially, a policy and program response of the government to the deficiency of urban shelter is focused on the public housing schemes and slum clearance.

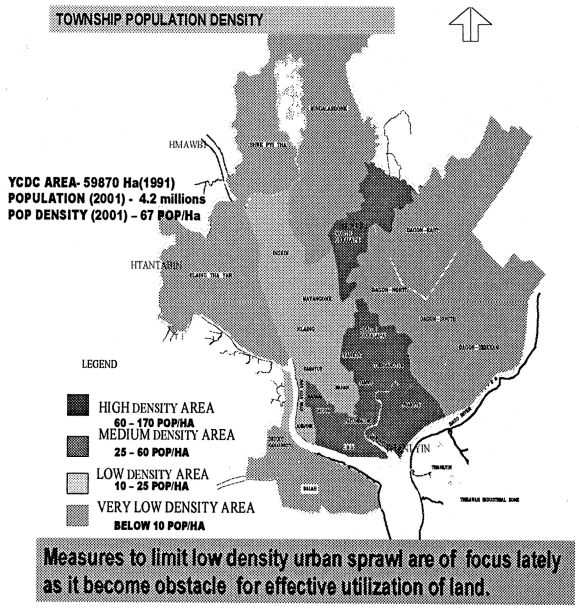

Fig. 4. Township Population Density.

The main housing delivery systems undertaken by the successive governments are:

a) Public and Rental Housing;
b) Government's Joint Housing;
c) programs for Individual Housing;
d) Sites and Services Schemes;
e) Slum and Squatter Upgrading (Hut to Apartment Scheme);
f) Urban Redevelopment Projects;
g) Area Development Projects;
h) Low Cost Housing.
i) Industrial Zone Development and
j) Provision of social Infrastructure

Significantly large sites and services schemes have been implemented after 1989. Approximately 160,000 plots for round about 400,000 persons have been developed in three new settlements to the east, west and north of Yangon. About 200,000 populations of squatter settlement dwellers have been provided with land lease on plots with basic infrastructure [4].

Out of 253050 plots developed from 1990 to-2000, 88180 plots (28%) were allocated to senior government employees. However, due to the high vacancy rates of plots (20%) in new towns, the trend on housing emphasis changed to slum upgrading, hut to apartment projects and low cost housing projects in suburban areas [4].

By mobilizing private sector participation in slum and squatter upgrading schemes, the role of the State has changed from provider to facilitator. Prior to 1988, there was no dedicated industrial zone in Yangon. The private industrial enterprise law promulgated in November 1990 has allowed the promotion of private sector development and the direct foreign investment.

During 1997 to 2000 there are 46 schools facilitated and constructed by DHSHD in Yangon city and its environs. The DHSHD and private developers have

contributed total development cost of 855.2 million Kyats.

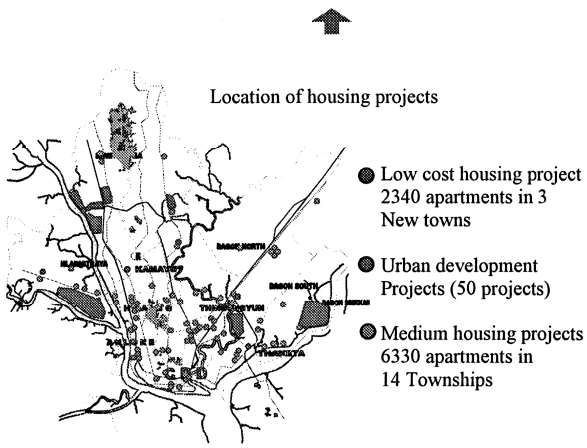

Fig. 5. Urban Densification (1993 onwards).

At present, Yangon is the most dominant city and may be described as a primate city accounting for more than 52.74 percent of total urban population. The present (2005) estimated population of Yangon City is almost four times bigger than Mandalay, the second city.

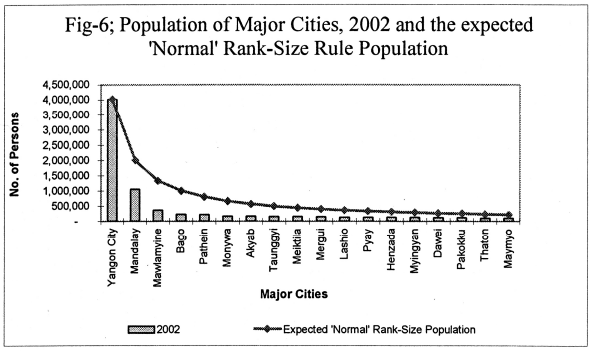

Fig. 6. Population of majot cities, 2002 and the exected "Normal" rank-size rule population.

The urban hierarchy of Myanmar deviates considerably from the 'normal' rank that follows the rank-size rule which states that the 'normal pattern' is one in which the second city is about half the size of the first city, the third city is about one third of the largest and so on. (See-fig-6)

It appears that in an open and free enterprise economy, the main factors i.e. size of city, its income level and accessibility seem to be the major influence on its growth rate.

7. URBAN INFRASTRUCTURE DEVELOPMENT

7.1 Water Supply System

Yangon obtains its water from sources such as rivers and lakes. Most of water bodies are located outside the Yangon City boundary. Water is also tapped from the ground for the daily needs.

At present only 46 percent of Yangon's population of 4.3 million is serviced with piped water supply. There is still a large proportion of the city's population being denied of clean water supply.

In recent years, demand for water supply is based on two sources; they are surface water and ground water resources. Daily demand for Yangon City is about 439,440 m^3/day and supply from three reservoirs, their daily capacity is just 393, 550 m^3/day. The rest of 45,890 m^3/day was supplied from the tube wells.

Rapidly increase of population and city area, more industrial zones, residents, commercial activities and emerging of he new satellite tows call for more water demand for the future. Estimation of demand for Yangon City is about 61, 3642 m3 per day for the future. YCDC plans a long term and short term projects for regular water supply. After these projects will be completed, 78% of whole city's water demand will be covered and amount of consumption will be 182 lpcd (40 gal per capital per day).

7.2 Sewerage System

Existing sewerage system was established in 1888 and consists of gravity sewer lines, 39 Ejectors, air distribution lines and two sewer force main to the river. The collected sewerage is distributed to the Yangon River without any treatment. The central sewer system in CBD covers an area of approximately 1.7 square miles. It was installed about a century ago to serve about 40,000 people. It is now over loaded and untreated raw sewerage was discharged through two outlets into the Yangon River.

The present sewerage and sanitation practices in Yangon have been categorized into four different types, such as conventional sewerage system (central sewerage system), septic tank system, and pour flush system, fly proof (chute type) latrines.

7.3 Road Network System

Yangon City's road network is still ground network system. Urban express way or elevated ways are not yet implemented and urban rail-way system also occupied a small portion of over all transportation networks. There are 2960 kilometers of the road networks (assorted lanes measurement) in Yangon City. Road networks have already expanded to northeastwards from the CBD. In the CBD the trunk road and streets followed a grid pattern and in the urban area (outer CBD) is a mesh-style road networks.

Travelers and commuters from national wide can access to Yangon City by using six national high way Roads conveniently. And then, inhabitants who live in urban fringe, especially in satellite towns and expansion areas can easily access to downtown (CBD area) by using arterial roads and collector roads.

7.4 Solid Waste Management System

As it is happening in most major cities, the waste management problem has already become severe in Yangon City. The problem is compounded by the rapidly increasing amounts of wastes of complex nature and composition, which result from the growth in the city's

population and the changes in the consumption patterns.

Solid waste generation in the city in 1999 was at about 3,000 tons per day. Due to rapid increase in urbanization area of Yangon City becomes wider and Pollution Control and Cleansing Department has to collect the solid waste in large extent across the area of city. However, gradual increase in population cause the generation rate in regular order and the amount of waste in each year is stated as follow:

Year	Amount of waste generator
1990	0.40 kg / cap / day
1995	0.48 kg / cap / day
2000	0.52 kg / cap / day
2005	0.62 kg / cap / day

The features of solid waste management in Yangon city are basically labor-intensive and uncontrolled. It is reported that the waste collection ratio in Yangon City is only 50– 60%. In the area of urban expansion, solid waste collection system does not properly operate like as main city Yangon. Residents commonly dispose of their solid waste into the alleys, streets, BDS (Back drainage space) rivers, channels, and drains/ditches indiscriminately.

8. CHALLENGES OF DEVELOPMENT

Some of the key issues and challenges identified in this study and are as follows:

- Up to now only sector planning approaches are existed. There is high demand for integrated planning based on a city wide land use planning.
- Legal framework regarding land use planning is missing completely.
- Citizen within a land development process have no rights. The process and compensation are not transparent.
- The level of population growth and migration are the main demographic issues related to the planning of Yangon City. The level of population growth is affected by economic condition of the city, demographic factors such as migration and natural increase, the capacity of infrastructure and facilities to support the population growth.
- Given the geographical position of Yangon City as a gateway linking Myanmar to the outside world, the effect of growth resulting from international trading will be received by the region within and around Yangon City. Under a more liberal economic scenario, the growth of Yangon City population is expected to be higher. In order to address and amend the strategic plan to accommodate any major changes to level of growth.
- Migration is major component of population growth of Yangon city. The domination of Yangon city in the hierarchy of urban settlement in Myanmar and disparity of living condition between Yangon City and the rest of the union may encourage people to move to Yangon city in the hope of earning better future. This will end up in massive unemployment or underemployment, slum and related social problems in the city.
- Need to prepare a detailed city plan and an overall infrastructure plan.
- Need for a comprehensive City Planning Act and related rules and guidelines.
- Application of GIS in city planning and land administration.

9. TRENDS AND RECOMMENDATIONS

By viewing in urban growth patterns, the city was initially built around the port area covering two sq-km. Based on old official maps, the built up area for the city increased rapidly from 13,244 ha (1970) to 27, 273 ha (1990) and 43, 284 ha (2000) [2]. It is expected that future growth will be mainly directed to the east in the Dagon Myothit Area and across the Bago River to Thanlyin where port activities at there are expected to spur development there. The area to the north in Mingalardon is not expected to see extensive development due to its remoteness from the CBD and other limiting constraints such as water catchments area for city water supply and a wildlife reserve. Further developments to the south of CBD will depend on the provision of road and bridges to these areas.

According to the development densities, Yangon City is 54.73 populations per hectare (compared to 76 pop/ha for Kula Lumpu). Some of the higher densities are found in the Kyauktada Township at 779 pop/ha and Latha township at 471 pop/ha both of which are found in IUR. Densities of outer-ring included townships within 10 km is about 250 pop/ha. The development densities in the New Town Areas (NS) are less than 100 pop/ha which is reflective of suburban densities. There is also noticeable trend towards suburbanization in north east and south-east area of Yangon by fulfilling the public transport and creating jobs.

The city which has been developed to an elongated shaped until 1989 has been changed to a cross shape. In future, that will have positive impact on city transportation and road network. From the cross shape, Hlaing Thayar, Hlaing, Mayangone, and Dagon North have formed the east-west axis and CBD, Bahan, Yankin, Mayangone and Mingalardon have formed the north-south axis. The secondary center should develop in the central place of Hlaing and Mayangone townships.

Before 1988, the land use classification is not systematic and clear in Yangon city. Most of industrial zones are existed in residential area, especially located in Inner Urban Ring (mostly in Hlaing Township). In 1988, these area were moved on to urban fringes like as Hlaing Thayar, western part of Yangon city across the Hlaing River, Shwe Pyithar, northern part and DAGON East and South, eastern of the city. Whole sale and large commercial area existed in CBD only and regional wise trading centre are shifted to the western part of Yangon city. Before this occasion, these are in Downtown (CBD)

and mixed up with residential area. Between 1989 to 2002, government tried to develop urban densification projects by three phases (1989-1993, 1994-1998, 1999-2002). Most of them are area development projects and Huts to apartment projects. The Fig.5 showed the urban densification projects by 1993. Their objective tends to upgrade the slum and squatter area and the people to live in the better living condition.

In my opinion, it is showed that the changes of land use after 1989 by establishing new industrial zones and implementing high rise apartments in northern, eastern, and western part of the city. So, the shape of city changed to an elongated shape to a cross shape. It will be better impact on the city transportation system. In overview the land use of industrial area were be totally changed and its development tends to be a heavy industrial zone. Residential areas are more spread out to the sub-urban area than that of before 1988. Former slum and squatter area were upgraded to the luxury housing projects and shopping center.

In these development projects, it can be seen that there are cultural changes of inhabitants. They are poor and lived together with 3 tiers family in their huts. In these new apartments, they are not enough space to live together, but they really live with together. They don't properly know how to live in it. They destroyed their living environments throwing their garbage and plastic bags and other solid waste disposal around their buildings. So, drainages and back lane are full of plastic bags and floods are caused by the rain season.

So, it is clear that there are not environmental friendly issues. They do their environment degradation. To maintain their status of sustainable city, inhabitants live in newly projects should be awareness of environmental concerns. They should learn more about the public participation and cooperation in environmental issues.

With more than 50% of people belongs to lower income bracket, and effective and efficient housing policy is an urgent necessity in order to provide housing for the majority of the population. It is therefore not recommended to increase the city area but to restructure and densify low-density area of western, eastern and northern areas of the Yangon city.

The city authorities and planners attempting to meet the challenges of growing population and increasing pressure on infrastructure have become conscious of the need to employ innovative approaches in city governance. In the context of maintaining the status of sustainable city, synergic efforts in term of public private partnership has become on essential element.

10. CONCLUSION

Yangon is and will be one of the most important urban centres of Union of Myanmar. The city has grown rapidly in recent years (expected to become a mega city in 2026) and new suburban satellite townships have been developed by the government to accommodate the increasing population and resettle inhabitants from the congested inner CBD area.

To maintain the image of Yangon as a livable and sustainable city, there is an urgent need to establish comprehensive city planning and urban development law. This law should be a comprehensive law covering aspects related to the use, development and conservation of land and building in the city. This law should be cover aspects pertaining to the types of Statutory Development Plans, Urbanization Promotion Areas, Land Readjustment, Land and Building Development Control, Planning Proposal Reports, Environmental Impact Assessment, Social Impact Assessment, Heritage Buildings and Conservation Areas including Environmentally Sensitive Area, public participation, enforcement as well as appeal procedures. In addition to planning laws, it is important to establish rules and guide lines.

And also, there is an urgent need to prepare a Detailed City Plan and over all Infrastructures Master Plan to guide, promote and control the development of the city. The plan should include land use zoning and building controls, as well as infrastructure plans covering key aspects of roads and urban transportation, urban drainage, waste water treatment and solid waste disposal. The present strategic plan could be serve as basic for it.

This research work recommends where and how new establishments should be located and what is to be protected in Yangon CBD and Whole Yangon City area.

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NOMENCLATURE

CBD = Central Business District,
IUR = Inner Urban Ring
OR =Outer Ring, SCBD=South of CBD, OSU=Older Suburb
NSU = Northern Suburb, NS=New Suburbs
I = Economic Activities, II=Social Services and Facilities
III = Transport and Communications Services and Facilities
IV = Recreational Activities, V=Community Organization
VI=Protective Services, VII=Infrastructure and Maintenance Facilities, VIII=Personal Services

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APPENDIX

Population size and Density by Townships, Yangon City (1993-2005)

Sr. No.	Township	Population			AAGR (%)		Area	Density
		1983	1993	2005	1983-1993	1993 – 2005	Sq.Killo	(pop/ha)
1	Ahlone	51,849	41,292	50,094	-2.25	1.62	2.59	193
2	Bahan	102,112	89,450	109,528	-1.32	1.70	8.81	124
3	Botahtaung	49,168	50,025	60,508	0.17	1.60	2.59	234
4	Dagon	35,541	35,360	46,590	-0.05	2.32	5.18	90
5	Dagon (East)*	0	0	69,902	-	6.66	110.4	6.3
6	Dagon (North)	0	75,035	122,899	-	4.20	118.53	10
7	Dagon (Seikkan)*	0	0	23,154	-	6.67	90.52	3
8	Dagon (South)	0	81,523	178,026	-	6.72	159.92	11
9	Dala	54,167	66,769	90,455	2.11	2.56	10.36	87
10	Dawbon	49,967	61,592	95,286	2.11	3.70	3.63	262
11	Hlaine	171,687	174,494	189,498	0.16	0.69	12.96	146
12	Hlaingtharyar	0	148,878	240,164	-	4.07	67.63	36
13	Insein	221,307	213,435	280,468	-0.36	2.30	19.98	140
14	Kamaryut	75,177	71,969	97,064	-0.44	2.52	6.22	156
15	Kyauktadah	37,634	40,806	50,914	0.81	1.86	0.52	779
16	Kyeemyindaing	69,866	80,823	101,112	1.47	1.88	5.18	195
17	Lamadaw	41,663	41,356	46,009	-0.07	0.89	1.20	354
18	Lathar	31,061	33,456	36,802	0.75	0.80	0.78	471
19	Mayangon	152,616	163,680	212,895	0.70	2.21	25.91	82
20	Mingalar-Taung-Nyunt	110,435	118,077	123,090	0.67	0.35	5.18	238
21	Mingalardon	124,652	145,092	200,941	1.53	2.75	29.02	69
22	North Okklapa	190,905	233,599	343,133	2.04	3.26	12.96	264
23	Pabedan	41,913	45,205	54,515	0.76	1.57	0.52	1048
24	Pazundaung	38,806	36,186	44,150	-0.70	1.67	1.04	424
25	Sanchaung	68,867	69,972	91,773	0.16	2.29	2.54	354
26	Seikkan (Port)	5,285	1,653	1,513	-10.97	-0.73	0.78	19
27	Seikkyi-Khanaungto	15,393	18,974	30,897	2.11	4.15	5.70	54
28	Shwepyithar	0	96,154	220,361	-	7.16	39.12	56
29	South Okklapa	183,264	198,398	255,776	0.80	2.14	10.36	247
30	Tarmwe	119,914	134,819	144,713	1.18	0.59	5.18	279
31	Tharkayta	193,028	225,683	332,255	1.58	3.28	12.96	256
32	Thingangyun	194,100	220,480	278,256	1.28	1.96	11.40	244
33	Yangkin	82,646	83,530	128,172	0.11	3.63	5.18	247
	Total Yangon City	**2,513,023**	**3,097,765**	**4,350,913**	**2.11**	**2.87**	**795**	**54.73**

Source: Adapted from Department of Population, Union of Myanmar

**Growth based on 2002-2005 figures Note: *AAGR = Average Annual Growth Rate*

Constraints in Achieving Urban Environmental Sustainability in the Muslim Country, Pakistan: An Islamic Perspective

Neelum Naz

Abstract— *Throughout history, cities have never been free of problems, whether built, social and environmental. However, some have been more successful than others in creating environments conducive to the cohabitation of a diverse population. Solving the problems of the developing world is a massive challenge as they are focus of development in industrial and social sectors. As a result, people are being confronted with juxtaposition of the international and regional, modern and traditional, industrial and technological etc. Unfortunately, the developing world comprising mainly of Muslim countries is threatened by environmental degeneration and social stratification. Islamic Republic of Pakistan is no exception and is in the limelight due to war against terrorism. The major cities are badly suffering from haphazard urban sprawl, environmental degeneration, energy crises etc. In the absence of long term policies, short term solutions are preferred over long term solutions making conditions more chaotic. It is high time to set things in the right direction by taking revolutionary measures in all institutions. Islam provides a comprehensive framework for the social and physical well being of mankind. Sadly, most of us are not aware of this rich legacy of environmental consciousness ultimately leading to sustainable development in Islam. The argument is made that sustainable environment: social and built, cannot be achieved in Pakistan or any other developing country unless the thinking patterns are changed substantially. As the entire focus of sustainability is on ethics so the objective of this study is to rediscover and refresh the teachings on ethics in the light of Quran and Shariah. The author being an architect felt inclined to highlight prevailing urban environmental conditions in the major cities of Pakistan to initiate a discourse at the national level to formulate future policies. The data used in this paper has been derived from the revealed and worldly published documents as well as electronic media.*

Keywords— **Developing World, Urban degeneration, sustainability, *Islam, Quran, Shariah*.**

1. INTRODUCTION

"Our survival the way Almighty Allah has ordained is possible only if we follow the principles of Al-Quran", Khan, M. S. 2005 [1].

The term "Sustainable development" entered into common vocabulary with the heightened awareness in the late 1980s. Though the term is widely used in reference to ecological sustainability but concept and aspects included in it may potentially be physical, cultural, social, political and doubtless many more. There is no consensus as to what the term means and has many definitions in consequence. The dictionary suggests different meanings such as "to keep up the strength, spirits or determination of", "to suffer", "to hold up" and "to keep in existence over a long period" [2]. In some cases, it is used simply to mean that the long term result of some action or set of actions is consistent with the desired solutions.

Brundtland Report "Our Common Future" in 1987 based on the findings of World Commission on Environment and Development (1983) gave the first clear definition as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Its three crucial dimensions: economic development, social equity and the preservation of the environment needs to be integrated and reconciled within a holistic and balanced sustainable development framework [3] [Figure 1]. According to the British government, sustainable development aims to guarantee a better quality of life for everyone, now and for generations to come. This cannot be achieved by meeting four goals at the same time: progress of all people by recognising their needs, protecting the environment, careful use of natural resources and maintaining healthy economic growth and employment [4].

2. SUSTAINABLE DEVELOPMENT: AN ISLAMIC PERSPECTIVE

The term environmentalism was coined in the west during 20th century as an aftermath of Industrial revolution but was revealed to the prophet of Islam, Muhammad (peace be upon him) 1400 years ago. Islam is not a religion; it represents an entire sense of community and a guidance framework for actions in all spheres of life [5]. The *Quran* (last divine book after Torah and Bible) *Shariah* (Islamic rules & ethical principles) are the primary sources of Islamic teachings. Quran says: "*…and verily, you (O Muhammad) are indeed guiding (mankind) to the straight path*" [6].

In order to understand Islam's response to sustainable development, we need to appreciate that Allah has created the universe and everything in it according to a perfect balance which we are required to obey and promote.

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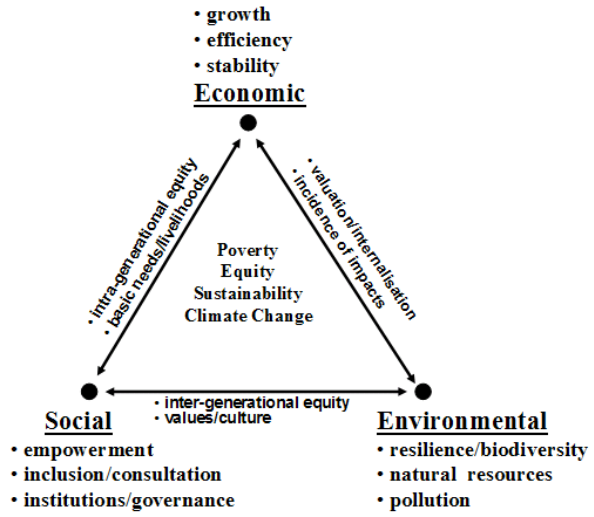

Fig. 1: Sustainable development triangle – key elements and interconnections (corners, sides, center). (Source: Munasinghe, M., retrieved from http://www.eoearth.org/article/Economic,_social,_and_environmental_elements_of_development

"*And the Heaven He has raised high, and He has set up the balance. In order that you may not transgress (due) balance, and observe the weight with equity and do not make the balance deficient*" [7].

There are over 500 verses in the *Quran* giving us guidance on matters relating to the environment and how to deal with it and there are numerous examples from the Prophet's Muhammad's life and his sayings, which provide a model for justice and equity [8]. The *Quran* explains that mankind holds a privileged position among God's creations on earth and is chosen as *khalifa*, "Vicegerent" and carries the responsibility of caring for God's earthly creations [9]. Qur'an repeatedly warns believers against arrogance and acknowledges that mankind is not the only community to live on the earth:

"*There is not an animal in the earth, nor a flying creature flying on two wings, but they are peoples like unto you*" [10]

Man is reminded through *Quranic* revelations not to waste any resource and the most remarkable point in this regard is that we shall be called to account on the Day of Judgement for how we used all the favours Allah had given us in this life:

"*O Children of Adam! Wear your beautiful apparel at every time and place of prayer: eat and drink: But waste not by excess, for Allah loveth not the wasters.*" [11]

Shortly, Holy *Quran* is not a collection of dogmas, but a complete code of conduct for mankind for all times to come. It draws attention on practically everything in the Nature [12]. The creator of universe talks about the creation of man, sun, moon, earth, mountains, oceans, clouds, birds, animals, day and night, rise and fall of nations and cities, historical events and mythical wonders.

The idea that Prophet Muhammad (peace be upon him) was a pioneer and strong proponent of environmentalism may seem an exaggeration in the west but many accounts of his life and deeds reflect that he had a profound respect for fauna and flora, as well as an almost visceral connection to the four elements, earth, water, fire and air. Chatles (2003) ranks him as a pioneer in the domain of conservation, sustainable development and resource management, one who constantly sought to maintain a harmonious balance between man and nature [13]. He mentions that:

"*…his environmental philosophy is first of all holistic: it assumes a fundamental link and interdependency between all natural elements and bases its teachings on the premise that if man abuses or exhausts one element, the natural world as a whole will suffer direct consequences*."

He further describes that the Prophet believed in sharing of the earth's resources and earth had rights, just as the trees and wildlife living on it. He was also a strong proponent of the sustainable use and cultivation of land and water, proper treatment of animals, plants and birds, and the equal rights of users. He says:

"*All creatures of Allah are His family; and he is the most beloved of Allah who loveth best his creatures*" [14]

The Prophet not only encouraged the sustainable use of fertile lands, he also told his followers of the benefits of making unused land productive: planting a tree, sowing a seed and irrigating dry land were all regarded as charitable deeds. Certain passages of the *hadith* (sayings/anecdotes of Muhammad) can be relevant in creating awareness and resolving contemporary environmental issues. For example, of reforestation and land reclamation, the prophet has said:

"Whoever brings dead land to life, that is, cultivates wasteland, for him is a reward therein."[15]

"*Whoever plants a tree and diligently looks after it until it matures and bears fruit is rewarded.*" [16]

"*There is none amongst the believers who plants a tree, or sows a seed, and then a bird, or a person, or an animal eats thereof, but it is regarded as having given a charitable gift for which there is great recompense."* [17]

In order to protect land, forests and wildlife, Muhammad (peace be upon him) created inviolable zones known as *hima* and *haram*, in which resources were to be left untouched. Both are still in use today: *hima* applies particularly to wildlife and forestry and usually designates an area of land where grazing and woodcutting are restricted, or where certain animal species are protected *haram* areas are often drawn up around wells and water sources to protect the groundwater table from over-pumping [18]. The six principles highlighted by *Shariah* for a value society; social cohesion (*Ummah*), responsibility (*Faradh*), empowerment (*Shura*), equilibrium (*Al'adl wal ihsan*), endowment (*Al-Waqf*) and almsgiving (*Zakat*) are in fact the main indicators of sustainable development agenda of

sustainable development [19]. Sadly, most of us are not aware of this rich legacy of environmental consciousness and socio-economic justice in Islam and how these relate to our contemporary issues.

"Islamic Declaration on Sustainable Development, Johannesburg, 2002"is the first comprehensive document highlighting Islamic perspective on sustainable development on the world forum. One of the organizations instrumental in the preparation of the document was the Islamic Educational, Scientific and Cultural Organization (ISESCO). ISESCO held jointly with the OIC a number of activities in this regard: a conference of governmental experts of the Islamic countries on sustainable development in Tunis (March 2001), the First Preparatory Meeting of the Environment Ministers of the Muslim World in Rabat (January, 2002) and the First Islamic Conference for Ministers of the Environment in Jeddah (June, 2002). The Declaration was presented at the World Summit on Sustainable Development (WSSD) held in Johannesburg in Aug. 2002. It proclaimed that "the sustainable development begins with an application of human rights and then extends to answering the rights of other creations". The Muslim World was supportive of the regional and international efforts exerted to promote the standard of life of all human beings of all aspects: social, economic, cultural, environmental, and health [20].

"Committed to the Islamic approach built on promotion of man's dignity and achievement of his lieutenancy mission on earth through good deeds that conduce to sustainable development, foster social solidarity, raise the care to orphans and the have-nots, induce edification of civilization without any plundering or dilapidation and affirm the organic relationship between man and the earth in terms of existence and development".

The "Article 3" and "Article 4" focus on environment from an Islamic perspective and human right to environment respectively [21]:

The environment is a gift donated to man by Allah. Therefore, individuals and communities are, all, duty-bound to take care of it and promote all its natural resources, including air, climate, water, seas, flora and fauna, and refrain from any act likely to cause pollution or damage the eco-system or disturb the balance thereto.

"*The right to education and to a decent life shall be recognized as well as the right to a sound, hygienic environment. The State and the society shall secure these rights to enable the individual to fully enjoy his humanness and contribute to the sustainable development of his community. Women shall also be recognized as full partners in the sustainable development action*".

The "Article 5" focuses on the major constraints of sustainable development: Poverty, Debts, Wars, armed conflicts and foreign occupation, overpopulation, particularly in cities of developing countries and the deterioration of living conditions in shanty towns and absence of modern technologies and technical expertise necessary for the implementation of sustainable development programs and plans etc.

3. URBAN SCENARIO OF PAKISTAN

Pakistan, the first Islamic nuclear state, had been colonized by imperial power before it became an independent state in 1947. The country has the second largest Muslim population in the world after Indonesia and the Muslims comprise 96% of the total population. Currently, Pakistan is in the limelight being an American alley in war on terrorism. Due to growing global anxiety over control of oil resources in Central Asia, conflicts in Iraq, Afghanistan and Kashmir, Pakistan is thrust upon with superpower politics, foreign aid, influx of Afghan refugees, Internally Displaced People (IDP) etc. The country is suffering from social injustice, corruption, ineffective policies, environmental degradation, mismanagement of resources etc. and being threatened by socio-political upheaval. Another challenge is the intolerance towards the diversity of views which continues to pull urban Pakistan in different directions. The schism is getting wider between religious clerics, enlightened moderation and traditionally determined social structures. Except for the affluent class, common individual is striving for their basic needs for survival. The historical Long March on March 15, 2009 was the national public protest against many ills predominantly social injustice which was telecasted world over. The country is on the brink of facing energy crisis ahead which is not just due to deficiencies in natural or human resources but due to lack of long term planning. Global Quality of Living City -2007 ranked Pakistan as one of the lowest scoring destinations in term of Personal safety with its three largest cities Karachi, Islamabad and Lahore at 213, 203 and 192 respectively [22]. Public Opinion Survey conducted in March 2009 by the International Republican Institute (IRI) reflects people response to economic situation, security conditions, religious extremism and future direction [Figure 2]. The randomly selected sample consists of 3,500 adult men and women from 216 rural and 134 urban locations in 51 districts in all four provinces of Pakistan. The data was collected through in home, in person interview from a National representative sample of adult residents (18 years and above) of Pakistan [23].

A brief outlook of the urban scenario of Pakistan with approximately 33% of population residing is a reflective of chaotic conditions [24]:

- Pakistani society as a whole is suffering from mismanagement of natural and man-made resources. The politicians are attuned to manage national affair in a state of crises alone.
- Pakistani elite have hardly any concern for the public welfare. They would like to live in air-conditioned homes, drive in air-conditioned cars, work in an air conditioned offices and shop in air conditioned malls. Whereas, public is badly suffering from energy crisis: power breakdown, shortage of gas.

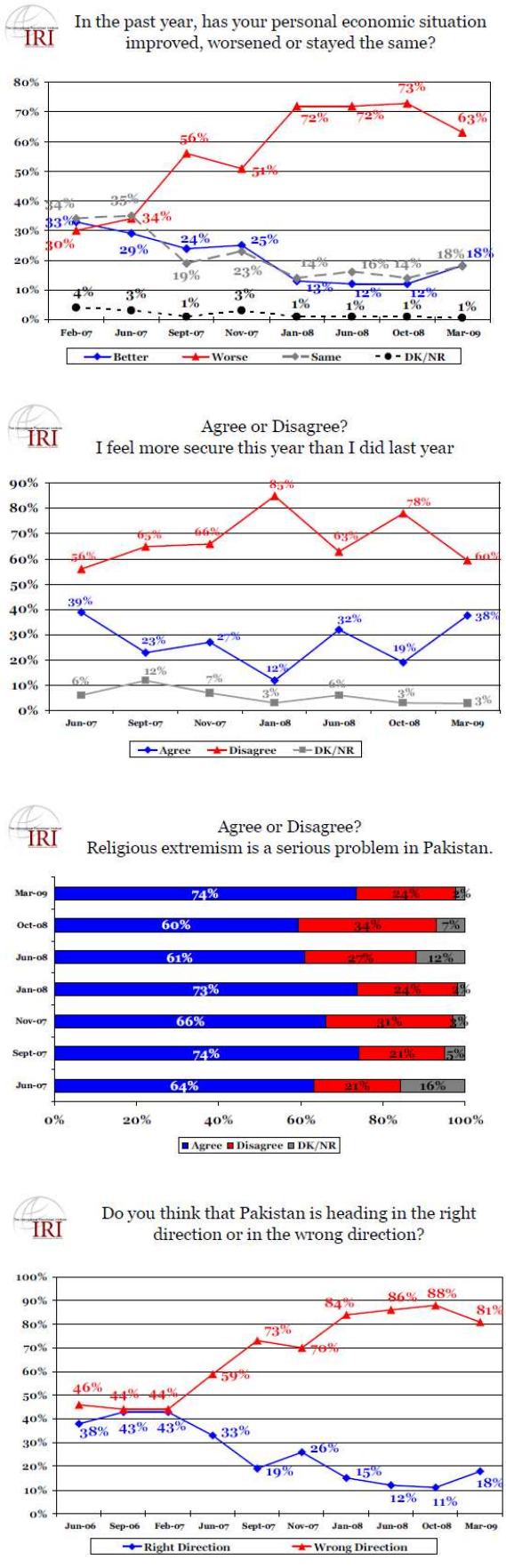

Figure 2: Public Opinion Survey of Pakistan by IRI

- In Pakistan, there has always been a wide gap what is preached and what is practiced. On the architectural scene, words such as regionalism, balance between man and nature etc. have become catchphrases with unfortunately no concrete results. The influence of regionalism is not even reflected in the works of architects who frequently comment and write on the subject. For many architects the principal concern is how to satisfy client's wishes; building form devoid of any social reference is the ultimate criteria. With very few exceptions, the architects are serving the interests of a very small affluent segment of the population who are devoid of the harsh realities of the society.
- Due to inadequate zoning regulations and even less implementation of these regulations, the existing infrastructure and support services are under enormous stress. Building after building simply appears with no discernable sense of purpose, direction or vision. This build –as much as you- policy has also caused a rampant increase in the urban land prices making it impossible for other developers to build within the permissible limits, and still be able to market their projects.
- The building by-laws are kept deliberately vague or ill defined so that they can be interpreted on a case-to-case basis depending on the relationship of the builder/architect to the authority concerned. Master Plans are degenerated /misused by both politicians and citizens. Individual benefits play more dominant roles than social benefits, in the determination of growth/developing directions of the cities. There are usually very little or no control exercised during execution, even if the physical construction has little relevance to the approved proposal.
- The prevalent market economy with no political directions is ensuring the architectural patterns are based on maximizing return on investment to a relatively small group, usually at the expense of the community at large.

Haider (2006) outlines the challenges in the largest cities of Pakistan regarding urban degeneration. He points out that the infrastructure deficit is the most obvious telltale of urban decay in Pakistan. Some indicators would help understand the scope of the problem [25].

Streets are littered with waste, drains are overflowing with sewage, low-ling communities are inundated after rainfall, traffic congestion is ubiquitous, and the violent crime in urban centers is on the rise…Less than 1 % of wastewater is treated in streams, ravines, and rivers have turned into sewers. The metropolitan governments recover fewer than 50% of the solid waste generated in cities. The rest is left on the streets. Even the waste that is collected is mostly dumped in open fields or is incinerated. The dumped waste pollutes the ground water and the incinerated waste creates air pollution…The poor economic growth, specifically the

low rate of employment growth for the youth, lack of entrepreneurship, and the collapse of civilian institutions are some of the more inherent causes of urban decay in Pakistan.

Lahore, one of the historical cities of Pakistan and is legendary for its historical buildings, and reminds us of the beautiful and wonderful history of the subcontinent. According to a UN report, Lahore is expected to be placed in world's mega cities category by 2025. It is a sprawling metropolis of seven million people and one of the thirty largest cities in the world. The relentless spread of this urban sprawl has resulted in severe pressure on the urban land and infrastructure of the city. At the time of creation of Pakistan, it was of the cleanest city, where all the facilities were available to the residents. K.K.Aziz, one of the senior historians writes [26]:

From the 1920s onwards, perhaps even earlier, Lahore was the most highly cultured city of north India…A glorious physical setting for this pulsating intellectual activity was provided by the Lahore that the British built between 1860 and 1935. Impressive edifices adorned the landscape… The queen of all roads, the Mall, was bordered by tall trees and wide footpaths, and boasted a glittering array of expensive shops. The Race Course and the Lawrence Gardens were the lungs of the city. No high rise buildings existed. With no encroachments the roads looked wider…The skyline was soothing. Nature's green was the dominating color of the city. Breathing was easy, and so was enjoying life.

Over the years the quality of life has gone down for the majority of citizens: drinking polluted water, breathing polluted air and eating polluted food. The flora and fauna is at risk. According to study conducted in 1992 only 101 bird species from the parks of Lahore were recorded which has reduced to just 85 including the resident and migratory ones. Land mafia is on the rampage in the provincial metropolis, traffic situation is alarming. Almost every main road is jammed due to the shortage of mass-transport system. Private car ownership creates enormous capacity problems. Over the last three and a half years, 35 illegal housing schemes have been launched in the city and after looting billions of rupees from thousands of people, sponsors of these schemes have simply vanished in the air. Provincial housing Department and Lahore Development Authority though declared these schemes illegal have failed to take any appropriate action. The authority has failed to evolve policies and programs relating to the improvement of housing schemes, industrial development, traffic, transpiration, health, education, water supply, sewerage, drainage and solid waste disposal. Khan writes [27]:

"*The Lahore Development Authority is fast becoming a white elephant in the eyes of Punjab Government. It is all due to rampant mismanagement, growing financial inefficiencies, inordinate delay in the implementation of commercialization policy, strengthening racket between LDA's employees and land grabber mafia*".

The conditions in other major cities of Pakistan are no more different. This is mainly for the reason that the right decisions have not been taken at the right time. To address the issue, the Ministry of Environment in coloration with the Ministry of Education decided to include chapters on environment awareness in school curriculum from class 1 and to initiate teachers' training program [28]. But so far, no concrete steps have taken to address the issue at a gross scale. In the midst of all the chaos, some development works are being carried, posh buildings are being constructed but a small section of society is the beneficiary. To measure the quality of life one should not look at the skyscrapers, the shopping promenades, parks and boulevards but to look at the quality of life of the people living over there. Undoubtedly, life for the majority of urban population has gone miserable, chaotic and complex.

4. CONCLUSION

Sustainability is holistic in nature as an infringement of one principle can often have repercussions on other activities. For example, it is impossible to consider poverty alleviation or pollution without addressing fundamental social, economic and political disparities leading to these miseries. The above cited urban condition of Pakistan reveals that human rights are not being protected and the breach between rich and poor is getting wider. Poverty, one of the major constraints to sustainable development, is on the rise and Pakistan is ranked 142 on the Human Development Index, compared to India 118 and Uganda 146 [**29**]. In addition, country is being threatened by religious extremism, suicide attacks, hunger, polluted water, air pollution, energy crises, shortage of affordable housing, etc which are the major constraints to sustainable development as pointed out by the "Islamic Declaration on Sustainable Development, Johannesburg, 2002" mentioned earlier. The question now arises can we talk of sustainable development without meeting the prerequisites and the immediate answer is certainly not.

The author is convinced that the factors surrounding sustainable development have ethical, social, and political complexities and that architects/planners alone cannot resolve the issue. The value system of a society as stressed by Islam is the ultimate grounding for the call to sustainability. The basic principles of sustainable development: equity, social democracy, concern for future generations, regard for human dignity are value based and environmental consciousness is born when such values are adopted and become an intrinsic part of our mental and physical makeup of daily life. It is pointless adopting this policy for political expediency and correctness while disregarding Holy Prophet Muhammad (peace be upon him) life's model of simplicity, peace, humility, brotherhood, contentment and modesty in our personal and social lives.

Long run development is not possible without protecting the rights of the vulnerable groups and the participation of the entire population in the development process. It is high time to mobilize the general public through seminars, educational programs, electronic and print media highlighting role of ethical values in the sustainable development we can religiously and

culturally identify with, and genuinely believe in. Above all what is needed more than anything is to bring change in our thinking individually and collectively to become instrumental to move in the right direction. The country created on the name of Islam should act as a role model for the other developing countries to follow. Let us take the lead in lightening the candle by brightening the forgotten legacy of Islam.

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In the Greater Mekong Subregion, home to about 250 million people, environmental degradation - including the decline of natural resources and ecosystems will definitely impact on the marginalized groups in society - the poor, the border communities especially women and children and indigenous peoples. The complexity of the challenges are revealed in the current trends in land and forest degradation and desertification, the numerous demands made on the Mekong river - to provide water for industrial and agricultural development, to sustain subsistence fishing, for transport, to maintain delicate ecological and hydrological balance, etc., the widespread loss of biological diversity due to economic activities, climate change and its impacts on the agricultural and river basin systems, and other forms of crises owning to conflicts over access to shared resources. The *GMSARN International Journal* is dedicated to advance knowledge in energy, environment, natural resource management and economical development by the vigorous examination and analysis of theories and good practices, and to encourage innovations needed to establish a successful approach to solve an identified problem.

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1. The manuscript should be written in English and the desired of contents is: Title, Author's name, affiliation, and address; Abstract, complete in itself and not exceeding 200 words; Text, divided into sections, each with a separate heading; Acknowledgments; References; and Appendices. The standard International System of Units (SI) should be used.

2. Illustrations (i.e., graphs, charts, drawings, sketches, and diagrams) should be submitted on separate sheets ready for direct reproduction. All illustrations should be numbered consecutively and given proper legends. A list of illustrations should be included in the manuscript. The font of the captions, legends, and other text in the illustrations should be Times New Roman. Legends should use capital letters for the first letter of the first word only and use lower case for the rest of the words. All symbols must be italicized, e.g., α, θ, Q_{wt}. Photographs should be black and white glossy prints; but good color photographs are acceptable.

3. Each reference should be numbered sequentially and these numbers should appear in square brackets in the text, e.g. [1], [2, 3], [4]–[6]. All publications cited in the text should be presented in a list of full references in the Reference section as they appear in the text (not in alphabetical order). Typical examples of references are as follows:

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   - **Proceedings reference** example: [3] Mayer, A. and Biscaglia, S. 1989. Modelling and analysis of lead acid battery operation. Proceedings of the Ninth EC PV Solar Conference. Reiburg, Germany, 25-29 September. London: Kluwer Academic Publishers.
   - **Technical paper** reference example: [4] Mead, J.V. 1992. Looking at old photographs: Investigating the teacher tales that novice teachers bring with them. Report No. NCRTL-RR-92-4. East Lansing, MI: National Center for Research on Teacher Learning. (ERIC Document Reproduction Service No. ED346082).
   - **Online journal** reference example: [5] Tung, F. Y.-T., and Bowen, S. W. 1998. Targeted inhibition of hepatitis B virus gene expression: A gene therapy approach. Frontiers in Bioscience [On-line serial], 3. Retrieved February 14, 2005 from http://www.bioscience.org/1998/v3/a/tung/a11-15.htm.

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