Sustainable Agriculture, Climate Change and Environment

Climate Variability and Drought Threats in Sindh and Balochistan Provinces of Pakistan

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INTRODUCTION

Drought is a complex phenomenon, which is difficult to define (Wilhite et al., 1985). As defined by the World Meteorological Organization (WMO), drought is a period of two consecutive years in which precipitation is less than 60 percent of normal in an area covering at least 50 percent of a geographical region (Weber, 1998). It is an episode of unusually low precipitation that causes damage to agriculture, ecosystems, and freshwater supplies (Heim, 2002). Ordinarily, it is defined as a lack of rainfall. Its severity would depend on the duration, moisture deficiency, and size of the area affected. This condition of having less than normal moisture spans over a year or two (Jensen, 2003).

Dry lands cover over 40 percent of the earth's land surface and support almost 20 percent of the human population (Thomas, 2002). More than 70 percent of Pakistan (87.80 million ha) is arid or semi arid. In these arid and semi-arid regions, rainfall is usually insufficient to support dryland and irrigated crops. Much of the soil is lost because of surface run-off or rapid evaporation due to high temperature (Suleman, et. al., 1995). This causes drought, which is coupled with prolonged dry seasons, influences growth and physiological activities of plants. This probably affects the survival of indigenous rhizobia (Athar and Jhonson, 1996, 1997a, b).

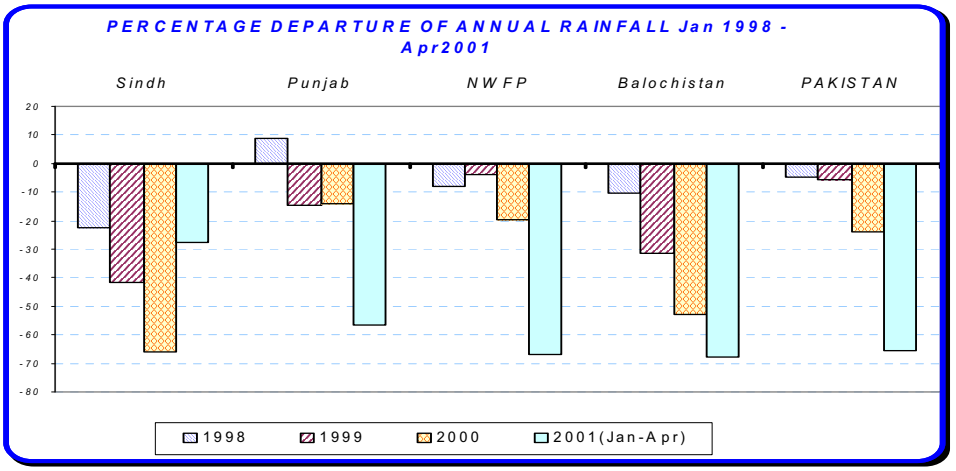
Drought Situation in the Study Area

The drought prevalent in the country during the last ten to fifteen years does not owe its existence to a single factor; rather it is the culmination of a number of elements. However, the single most important factor is the La Niña, which resulted in abnormal weather conditions that caused meteorological drought in vast areas of Pakistan. For the last ten years,

Pakistan has been experiencing this phenomenon that was responsible for the intense heat and minimal rains the whole winter and even in the months of April and May. This situation has impacted negatively on river flows and resulted in national tensions over supply of water as many canals have practically dried up and the others are operating with minimal flows.

Most of Pakistan is characteristically arid to semi-arid. The country embraces an area of about 800,000 square kms and is home to approximately 130 million people. Annual precipitation is highest (around 1,500 mms) on the southern slopes of the Himalayas and gradually decreases in the southwest. Only 9 percent of Pakistan receives more than 20 inches (508 mms) of rain per year. A further 22 percent receives between 10 to 20 inches (254 to 508 mms) and the remaining 69 percent receives less than 10 inches (254 mms). Rain falls primarily (70 to 80 percent) in the monsoon months of July, August and September over most of Pakistan. Unfortunately, rainfall in 1998 to 2001 all over Pakistan was recorded very less compared to the previous years (Fig. 1). It caused the greatest threat of drought in the major part of Pakistan especially Balochistan and Sindh provinces.

Figure 1. Percentage departure of annual rainfall January 1998 to April 2001



METHODOLOGY

Most parts in Pakistan come under the direct threats of prevailing droughts almost after every four to five years. Balochistan and Sindh provinces are most vulnerable and drought-affected and these are the provinces taken into consideration in this research. Mean monthly rainfall data was taken to determine possible effects of drought especially on the economy in the study area. Data gathered were analyzed using statistical methods and techniques. The major source of data is Pakistan Meteorological Department (PMD). Drought maps were also derived from

the PMD to see the possible variations in drought conditions in different time periods. The loss in the economy and crop production due to drought is highlighted in tabulated form. The data on economic loss was taken from Economic Survey of Pakistan and United Nation.

Drought-affected areas in Pakistan

In order to identify the areas vulnerable to drought, a study on rainfall activity all over the country was conducted for more than 50 percent of the time. Rainfall periods were winter (December to March) and summer monsoons (June to September). April to May and October to November are the transition periods. Very little rainfall occur in Sindh, Southern Punjab and Balochistan during these periods.

The Balochistan Province

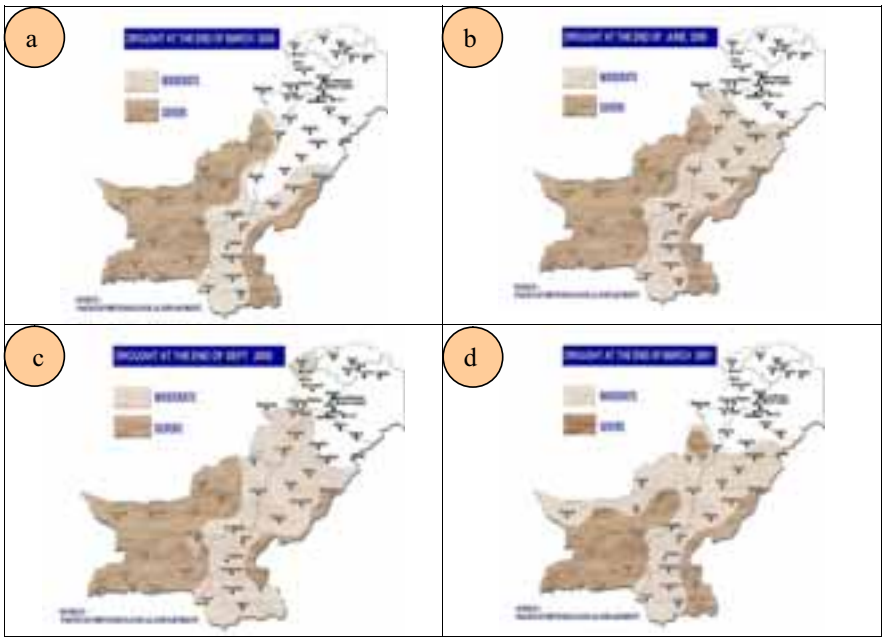
Balochistan was the worst drought-affected province in Pakistan in 1998-2001. About 88 percent of it was directly affected by drought worsening significantly its economic situation. The province received almost 50 percent of the normal rains during summer but winter rains turned out to be only 37 percent of the normal. Since the end of March 2000, the entire Balochistan province was experiencing drought (Fig. 2a). At the end of June 2000, the drought area further extended toward North West and at this time the whole province is already under severe drought (Fig. 2b), a problem that affected not only the local people but the whole country. In September 2000, the rainfall in the northern parts of the province minimized the drought severity in the north but drought in the southern parts remained severe until March 2001 (Fig. 2c,d). In July 2004, drought again prevailed in the southern and south western parts of Balochistan. However, drought in March 2004 was not as severe as that in September 2004 (Fig. 3). It was because of this that almost 1.09 million people and 10.65 million livestock in the province were directly affected. There were 16 people who died due to shortage of water, food and diseases. About 2.18 million livestock died due to shortage of supply of fodder, drying up of water reservoirs and vanishing of grasslands in the area. Since livestock is the major source of income of the province mass killing of livestock due to drought badly affected the economy over a long period of time (Table 1). A total of 1.973 million acres of cultivable land were also affected by drought.

The Sindh Province

Almost 18 percent of the area of Sindh Province also experienced severe drought. Eastern and south eastern parts of the province were badly affected by its long spell in 1998 to 2001. The Tahr Desert covering most of the areas in the east and southeast, usually receive less annual rainfall that is insufficient to the local people (Fig. 2a,b,c,d). Economic loss of 33 Billion Rupees of the province was mainly attributed to drought. The areas of Sindh that were worst affected by drought were Tharparkar, Mirpurkhas, Thatta and Sanghar districts. A total of 1.3 million of the population and 5 million

livestock were directly hit by it. About 127 people and 0.03 million livestock were killed due to severe drought in the area (Table 1).

Figure 2. Drought situations in Pakistan (a) March 2000; (b) June 2000; (c) September 2000; and (d) March 2001.



Impact to the Economy

The drought that is yet to show its full face already had a sizable impact on the economy of the country. The State Bank has calculated the effect of drought to the tune of $927 million in the third quarter. As a result of this blow to the economy, the anticipated GDP growth rate of 4.5 percent will not be achieved, rather, the GDP growth rate will fall to less than 3 percent resulting to the stagnation of the per capita income. As Pakistan is an agriculture-based economy, the major industries owe their production to the agricultural output which has significantly reduced due to the drought resulting to the country's increased dependence on imports which in turn adversely affected the "Balance of Trade" of the country. Another major setback that resulted from drought is the reduction of the country's ability to produce hydroelectricity due to lack of water. To remedy this, additional furnace of oil has to be imported for the production of thermal electricity further dwindling the foreign exchange reserves. It is estimated to cause an additional loss of nearly $ 1.2 billion to the country.

Impact on Crops Production

According to official sources, the losses in Rabi crops remained more than Rs. 28.50 billion. Wheat production went down by 2.57 million tons in

Table 1. Comparative effects of drought in Balochistan and Sindh provinces

	Balochistan	**Sindh**
Affected District	23 (88percent out of the total 26)	4 (14percent out of the total 21)
Affected Population	1.09 million (17percent out of the total 6.5 million)	1.3 million (4percent out of the total 30 million)
People killed	16	127
Affected Livestock	10.65 million (47percent out of the total 22.5 million)	5 million (21percent out of the total 23.8 million)
Livestock killed	2.18 million	0.03 million
	Balochistan	**Sindh**
Short-term Requirements	Food: 6,000MT (PKR 450 mill) Fodder: 490,000 MT (PKR2,170 mill) Medicines: - (PKR40 mill) Tents: 50,000 (PKR250 mill) Water bowsers: 200 (PKR 20 mill) Water tanks & water pumps: 2,000 each (totaling PKR 40 mill) Transportation, sheds and items of daily use: (PKR 50 mill)	Food: - (PKR 864 mill) Fodder: 40,350 MT (PKR 325 mill) Medicines: - (PKR 390 mill) Water supply: (PKR 25 mill) Repair of tube wells: (PKR 25 mill) Logistic support: (PKR 12 mill)
	Total: PKR 3,020 mill (USD 59 mill)	Total: PKR 1,641 mill (USD 32 mill)

2001 because of the drought. Wheat production was just 18.53 million tons in 2000-2001 as compared to 21.1 million tons in 1999-2000. Similarly, the losses during the Kharif season remained approximately Rs. 29 billion. Among the Kharif crops, cotton production fell from 10.6 million bales to 9.7 million bales costing Rs. 9 billion in 1998-2003. Rice production went down from 4.8 million tons to 3.9 million tons costing Rs. 10 billion. Sugarcane production was reduced to 35 million tons as compared to 44 million tons costing Rs. 10 billion (Table 2).

Table 2. Drought effects on crops production

Crop	**Production (million tons)**		**Loss (Rs. Billion)**
	1999-2000	2000-2001*	
Wheat	21.10	18.53	28
Gram	0.565	0.54	0.5
Cotton**	10.60	9.70	9
Rice	4.80	3.90	10
Sugarcane	44.00	35.00	9
Total	81.07	66.64	56.50

*Projected figures except for wheat **Cotton production in million bales

Impact on Livestock Sector

Livestock sector has also been affected very adversely by drought. Total loss to this sector all over Pakistan was estimated at almost Rs. 15 billion. Out of this total, Punjab suffered a loss of Rs. 5.5 billion, NWFP Rs. 4.4 billion, Balochistan Rs. 3.5 billion and Sindh Rs. 1.63 billion (Table 3).

Province	Loss (Rs. Million)	Affected Livestock Population (millions)
Balochistan	3,522	10.68
Sindh	1,631	5.08
Total	5,153	15.76

Table 3. Drought effects on livestock

Conclusion

The major occupation of the people of Pakistan is farming so the country is basically an agricultural-based economy. But unfortunately, more than 70 percent of the country's land is arid to semi-arid. Any kind of change in the climate greatly affects the social and economic condition of the people. During the last ten to fifteen years, Balochistan and Sindh provinces remained under the threats of drought. The most severe drought was experienced in 1998-2001 which killed people and livestock and practically changed productive lands into barren land. This severe drought also generated serious and long term effects to the economy of the provinces and the whole country. During this period, Balochistan and Sindh provinces only received 50 percent of the normal rains in summer and 37 percent in winter. In Balochistan, almost 1.09 million people and 10.65 million livestock were directly affected. About 16 people and 2.18 million livestock were killed. A total of 1.973 million acres of cultivable land was also affected by drought. In Sindh Province, almost 18 percent of its area experienced it. It caused an economic loss of Rs. 33 billion in the province. About 1.3 million human population and 5 million livestock were directly hit causing the death of 127 people and 0.03 million livestock. The people of Balochistan and Sindh suffered about Rs. 3,020 million and Rs. 1,641 million economic losses, respectively. This further caused mass migration of people to nearby areas hence creating more problems to the government and the populace in general.

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References:

Athar, M. and Johnson, D.A. (1997a). Effect of drought on the growth and survival of Rhizobian meliloti strains from Pakistan and Nepal. Journal of Arid Environment, 3: 335-340.

Athar, M. and Johnson, D.A., (1996). Nodulation biomass production and nitrogen fixation in alfalfa under drought. Journal of plant Nutrition, 19: 85-199.

Chaudhry, Q.Z., M. Munir Sheikh, Anjum Bari: History's Worst Drought Conditions Prevailed over Pakistan, (http://www.pakmet.com.pk/journal/historyworstdrought2001report.htm)

Heim, R. R. 2002. A review of twentieth-century drought indices used in the United States. Bulletin of the American Meteorological Society 83:1149–65.

Jensen, D.T. (2003). Monitoring Drought in the West. Arid Land Research and Management 17: 449–454.

Pakistan-Drought OCHA Situation Report No. 3, Ref OCHA/GVA 2000/0099, Pakistan, May 30, 2000.

Pakistan Meteorological Department (PMD), Drought/Environmental Monitoring and Early Warning Center, (http://www.pakmet.com.pk/drought/maindrought.htm).

Resident Coordinator of the United Nations System's Operational Activities for Development in Pakistan. Drought? Pakistan, Update Report No. 12, 8 June, 2001.

Suleman, S., Karl Wood, M., Shah, B.H. and Murray, L. (1995). Development of rainwater harvesting system for increasing soil moisture in arid rangelands of Pakistan. Journal of Arid Environment, 31: 471-481.

Thomas, D., Twyman, C., and Harris, F. (2002). Sustainable development in drylands: geographical contribution to better understanding of people-environment relationship. The Geographical Journal, Vol. 168(3): 193-194.

Weber, L., and Nkemdirim, L., (1998). Palmer's Drought Indices Revisited. Geografiska Annaler, 80A-2: 153-172.

Wilhite, D. A. and Glantz, M. H.: 1985, Understanding the drought phenomenon: the role of definitions, Water Int. 10, 111–120.

Comparison of Carbon Benefits Between Natural and Plantation Forests

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INTRODUCTION

One of the major concerns in environmental management and protection today is global warming understood as a phenomenon of increasing global surface temperature and the potential climate change of global magnitude due to the accumulation of atmospheric "greenhouse gases".

Greenhouse gases are atmospheric trace gases that keep the earth's surface warm. The most significant greenhouse gas is CO_2. Recent investigations show that CO_2 concentration is approximately 30% greater than it was in the 18th century (Michaelowa and Koch, 2001). Furthermore, Intergovernmental Panel on Climate Change (IPCC) second assessment report confirmed that greenhouse gases in the atmosphere continue to rise (IPCC, 1995) and it should be stabilized at the level that would prevent dangerous effects to humanity.

The influence of forest on climate is very important and well recognized. The climatic benefits of trees and forests are complex and occur at several scales. While forests' traditional uses have been substantially evaluated in terms of their monetary benifits, evaluation of C sequestration services is still limited. Several studies have been undertaken to estimate carbon dioxide fluxes as a result of land use changes. Other studies evaluated carbon uptake associated with reforestation and recovering forest vegetation. However, the uncertainty of the results arises from biomass and carbon content produced by these different types of carbon sinks in various regions or areas and differences in age levels, thereby resulting to varied biomass and carbon contents.

Estimates and measurement of the amount of C sequestered in different forest types and giving value to such forest services are necessary for effective management. Furthermore, they are necessary bases for policy

formulation regarding the preservation of natural forests, to answer the question of how many hectares should be preserved for carbon sequestration services and to determine the size of forest to be planted to maintain desirable carbon balance. Providing monetary estimates of C sequestration services may help decision makers, resource managers, and planners to make better decisions with regard to promoting preservation of natural forests especially watershed reserves that provide benefits aside from C sequestration/storage services while reducing land use changes. In addition, providing value for C estimates from plantations is necessary for C trading, parking, or storage agreement policies that are now in place in other countries and for justification of expanding the forest plantation ventures in the country.

Thus, a reliable measurement of carbon sequestered in the forest biomass of different forest types is needed and an up-to-date and a reliable estimate of the monetary value of C sequestration services is called for.

Objectives

In general, the study aimed to estimate the carbon benefits and potential economic value of carbon sequestration/storage services of the secondary natural forest and forest plantations in Aurora province. Specifically, it sought to attain the following objectives:

1. Compare the current amount of biomass and carbon benefits of a secondary natural forest and an eight-year-old *Gmelina arborea* plantation;
2. Compare the projected amount of carbon sequestered in one production period;
3. Estimate the economic value of C sequestration services of a secondary natural forest and a *Gmelina arborea* plantation; and
4. Provide basis for policy recommendation for the management and protection of existing natural forests as well as expansion of investments in plantation forests for their C sequestration services.

METHODOLOGY

The study was conducted in a natural forest in Diap-diapnan sub-watershed within the proclaimed Bazal-Baubo Watershed Forest Reserve in the municipality of Maria Aurora, Aurora province.

Other study sites are plantation forests. One is in the municipality of Dilasag and the other two sites are in Casiguran, Aurora.

Natural forest. In terms of sampling method, for the natural forest, a reconnaissance survey was done and secondary data like maps and watershed resources profile were gathered from the office of Aurora

Integrated Area Development Project (AIADP II) and the CENRO in Maria Aurora. The study site was divided into two with the Diap-diapnan river in between. Using the riverbank as baseline, a distance of 100-150m was measured perpendicularly from both sides of the river. Sampling plots were laid out, one plot on each side of the river. Succeeding plots were then established until 15th pair of sampling plots was identified.

Each sample plot was laid out on a 50m x 50m square within which were sets of subplots. A bigger plot size was used since according to Brown et al. (1992) this will increase accuracy of biomass estimates. The area of the plot was 0.25 ha and distributed inside the plot was a set of subplots for measurement of various resource types such as seedlings, saplings, shrubs, and large trees for biomass determination. The plot sizes for measuring trees and other resource types are as follows:

- 50m x 50m plot - trees with diameter at breast height (dbh) 10 cm and above
- 10m x 10m subplot - saplings and shrubs with dbh less than or equal to 9.9 cm
- 2m x 2m subplot - biomass of herbaceous and small woody vegetation with less than or equal to 1.5 meter height
- 1 m x 1 m subplot – litter, roots, and soil samples

In the plantation forest, three contiguous plantation sites with different age classes were identified for measurement. Establishment and plot configuration within the plantation forests were done in the same way it was done for the natural forest (for other biomass components of the forest aside from stem biomass).

Data Collection

Natural forest. Aboveground biomass estimate for trees with diameter at breast height of 10 cm and above was done by non-destructive sampling or non-harvest method and a total of 30 plots was taken. Total height, merchantable height, and diameter at breast height were measured within the 50m x 50m plot in the natural forest. All measurements for biomass determination commenced from the innermost subplot and tree species were identified. To determine the stem biomass density, two methods were used:

1. Allometric equation (Brown, 1997) used for wet environment; and the
2. Biomass density based on inventoried volume

Biomass for understorey vegetation. For vegetation less than or equal to 9.9 cm dbh found within 10m x 10m sub-plots, a stratified tree technique of harvest was used (Rochow, 1973; Negi et al., 1988). Saplings and shrubs were categorized into small size classes (2.0-6.0 cm and 6.1-9.9 cm dbh). Trees of different size classes were enumerated and two sample trees having

parameters (dbh and total height) close to the mean of the class were harvested. Trees selected for harvest were clipped at ground level and separated into main stem, branches, and leaves. All components were oven-dried at 105 ^{0}C to constant weight and sum of the oven-dry weights of the whole sample tree were determined. To get the biomass of all trees in that particular dbh class, the number of trees in a particular dbh class was multiplied by oven-dry weight of the representative tree harvested.

Biomass from the leaves. Biomass density was taken from secondary sources due to limited equipment for leaf area index measurement.

Biomass of herbaceous vegetation. Biomass of herbaceous vegetation and small woody vegetation was determined by harvest method. Vegetations less than or equal to 1.5 m in height was clipped at ground level. Clipped materials were weighed to determine fresh and oven dried weight.

Standing litter. Collection of standing litter organic mass was done once. Fresh and partly decayed organic materials were collected within 1m x 1m plot. Fresh and oven dried weight was determined.

Roots. Roots were sampled within the innermost plots after litter collection in one-meter depth. Fresh and oven dried weights were taken. Samples were collected after oven drying and sent to the laboratory for C analysis.

Total biomass per hectare for natural forest was done by adding the biomass in every forest component.

Plantation forest. The total number of trees in a hectare was taken depending on the spacing employed. To determine the biomass density of trees, leaves, herbage, standing litter and roots, the same methods used in the natural forest were used. No understorey vegetation biomass densities were taken.

Soil sampling. Soil samples were collected from both plantation and natural forests. Four soil samples were collected from the natural forest and two soil samples for each age class in forest plantation were collected. Soil samples were taken at 0-15 cm and 15-30 cm depths and mixed to have one composite sample for organic carbon analysis.

Carbon Content Determination

Carbon content analysis was done for all components. Total carbon stored in both forest types at the time of the study was determined by adding carbon content of each forest components.

Yield Prediction and Amount of C Sequestered After One Production Period

Biomass and amount of carbon stored for one cutting cycle and for one rotation period were determined.

Natural forest. The average number of trees per hectare was taken from the inventory conducted and used as baseline data to determine the amount of biomass and carbon in the next 30 years - the cutting cycle (CC) for climatic type 4. Since volume is the function of diameter and height (Tandug, 1992) periodic annual increment (PAI) equation of tree diameter for dipterocarps and non-dipterocarps was determined based on the equations developed by Virtucio and Uriarte (1999) for climatic type 4. For the average merchantable height increment for dipterocarps and nondipterocarps, the formula used was based from Beers (1962) as cited by Vallesteros (1998). To determine C content the following steps were done:

1. Diameter and height increment were projected yearly for 30 years.
2. Volume and volume increment were computed yearly for 30 years based from periodic increment in diameter and height.
3. Volume at a given year was determined using the formula
   VOB/ha = 0.7854 D2 H
   Where:
   VOB = volume over bark per hectare
   D = projected diameter in cm at a given year (Uriarte and Virtucio, 1999)
   H = projected height in meters at a given species group and diameter
4. Stem biomass density and carbon sequestered per year were determined based on the following formula:
   Stem biomass density = VOB * WD (0.57t/m3)
   Carbon content = Biomass density * % carbon content (53%)

It was assumed that all other forest components would have a constant value at the end of one production period.

Plantation forest. Data from fifteen-year-old *Gmelina arborea* plantation was used for a 15-year rotation period. Stem biomass density = VOB * WD (0.45t/m3)

Estimation of the Net C Sequestration Monetary Value

The monetary value of the C sequestration services of the two forest types were estimated using the benefits transfer method. The value was based on the assumption that the average value per ton C is US$ 5.00 (Sedjo and Solomon 1989; MacNally and Shahwahid (2001) and IPCC (2000).

Data Analysis

Data from the field as well as in the laboratory were tabulated and summarized for each forest type. Descriptive statistics such as percentages and means/averages were used.

RESULTS AND DISCUSSION

Biomass Production and Accumulation

Stem biomass production: Based from the data using allometric equation method, stem biomass production of natural forest was 81.02 t/ha. The largest fraction of aboveground biomass was accounted from biomass of trees in lower diameter that ranged from 10-20 cm.

The stem biomass was 73.21% of the aboveground biomass component (Figure 1) and 62% of the total biomass. Computed value of tree biomass in the natural forest was lower than the value obtained by Guillermo (1998) from the secondary forest in Mt. Makiling. Compared to the natural forest, an eight-year-old plantation forest has aboveground tree biomass densities of 66.12 t/ha and 86.26 t/ha for allometric and based from inventoried volume, respectively (Tables 1 and 2). Estimates of tree biomass were lower in plantation forests compared to the natural forest. Stem biomass density comprises about 85% of the aboveground biomass density in plantation forest (Figure 2). The trees in plantation sites have lower average diameter as compared to the natural forest where higher number of trees inventoried has around 10-20 cm dbh with an average dhb of 13.34 cm.

Table 1. Biomass density (t/ha) of natural and plantation forests using allometric method.

FOREST COMPONENTS	FOREST TYPES	
	Natural Forest	Eight-Year-Old *Gmelina arborea* Plantation
Stem	81.02	56.38
Leaf	2.84	1.98
Understorey	21.04	0.00
Herbage	0.45	1.36
Litter	5.31	6.41
Aboveground biomass	110.67	66.12
Belowground biomass		
Roots	20.61	6.12
Total	**131.28**	**72.24**

Figure 1. Relative percentage of aboveground biomass in natural forest.

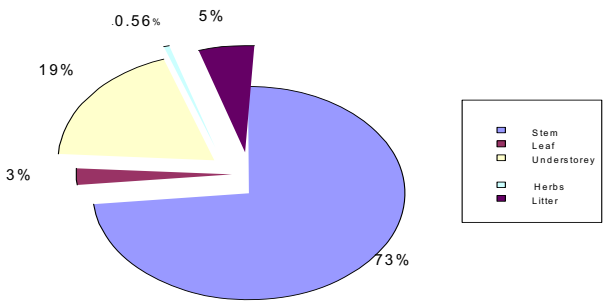

Figure 2. Relative percentage of aboveground biomass in plantation forest.

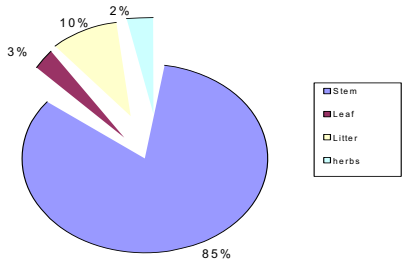

Table 2. Biomass density (t/ha) based on inventoried volume for natural and plantation forests

FOREST COMPONENTS	FOREST TYPES	
	Natural Forest	Eight-Year-Old *Gmelina arborea* Plantation
Stem	114.39	75.82
Leaf	4.15	2.66
Understorey	21.04	0.00
Herbage	0.45	1.36
Litter	5.31	6.41
Aboveground biomass	145.23	86.25
Belowground biomass		
Roots	20.61	6.12
Total	**165.84**	**92.36**

Understorey Vegetation. Understorey vegetation in this study consist of trees/ shrubs with diameter lower than 10 cm. For the natural forest, understorey vegetation biomass density was 21.04 t/ha (Table 1) comprising about 19.01% of the aboveground biomass that was higher than the results of Guillermo (1998). Higher understorey biomass density was due to the preponderance of seedlings and saplings in lower diameter classes. Based from Brown and Lugo (1990) and Lugo and Brown (1992), understorey shrubs and herbs in secondary forests may account for up to 30% of the forest biomass formation. Understorey biomass in plantation forest in Leyte amounted to 3.66 t/ha (Lasco et al., 1999) but estimates for this study cannot be made due to absence of understorey vegetation.

Herbaceous vegetation. In Table 1 about 0.45 t/ha of herbage for natural forests was accounted, however, value was lower compared to the findings of Zamora (1999), whose estimate was 1.12 t/ha of herbs in a coconut-coffee based multi-storey farm while Castro (2000) found 3.701 t/ha in an agro-forestry farm. Production of herbs and weeds could be attributed to canopy structure and management system of the land. Close canopy areas tend to inhibit growth of herbs and weeds because less light can penetrate.

Herbage production in the *Gmelina arborea* plantation was 1.36t/ ha, almost equal to the findings of Zamora (1999) and Lasco et al. (1999). Apparently, as the canopy closes because of bigger trees, the value for weed production decreases. The plantation forest has a wider spacing of 3m x 3m, which is favorable for weed growth. Maintenance of forest floor in well-managed plantation forest is done by underbrushing weeds and other grasses. Fern species dominate the weed and herbaceous vegetation in the plantation forest. Cogon and hagonoy with vigorous growth were found in other parts of the area.

Litter. Biomass density for natural forest was estimated at 5.31 t/ha as shown in Table 1. The amount of litter biomass was comparable to the data obtained by Guillermo (1998) in the secondary natural forest. As cited by Brown (1997) the amount of dead plant materials in the forest composed of fine litter may range from 2–16 t/ha or less than 5% of the aboveground biomass. However, for subtropical forests in Puerto Rico as mentioned by Murphy and Brown (1986), wood and litter account for 22% of the total biomass.

On the other hand, the *Gmelina arborea* plantation has higher litter biomass density of 6.4 t/ha (Table 1), than the natural forests. According to Lugo et al. (1990), the significant difference between natural and plantation forests is the production of litter. However, the values obtained in this study did not exhibit a significant difference. Plantation forests were regularly pruned to have a higher production of stem volume. Hence, there was a lower turnover of organic matter in the area. It was observed during the study that the lower branches were pruned and cut materials were not allowed to decompose on the ground as evidenced by the absence of decomposing twigs or branches in the soil surface.

The aboveground biomass and necromass density of natural forest was 110.67 t/ha as shown in Table 1. About 73% was contained in tree biomass while the rest were distributed in other forest components. Tree biomass density was lower compared to the results of Gillespie et al. (1992) in Castro (2000) where 96% of biomass was stored in bigger trees. Total biomass density is within the range of 50-700t/ha, for tropical forests in Southeast and South Asia (Brown et al., 1991; Murdiyarso and Wasrin, 1995). The aboveground biomass was still lower than the values obtained by Lasco et al. (1999) and Guillermo (1998) in natural forests because these studies were done in old growth forest.

In forest, aboveground biomass density was 66.12 t/ha and 85.27% was attributed to tree biomass. This value was higher than the estimates of Castro (2000) for an agroforestry farm dominated by *Gmelina* with 40.81 t/ ha at year five. The total biomass of 72.24 t/ha obtained in this study was

much lower than the value (187.57 t/ha) reported by Lasco et al. (1999) for an older plantation studied in Leyte.

Differences in biomass density for the two forest types, based on Kawahara et al. (1981), could be due to age and stem biomass or volume increase with forest growth. As trees grow older, their height and diameter increase resulting to increase in volume and biomass. Gillespie (1992) in Castro (2000), reported that 96% of the total biomass was found in bigger trees. According to Zamora (1999), diameter has a strong positive correlation with biomass where bigger trees produce more biomass. This may explain why plantation forests with smaller average diameter of only 13.45 cm have lower total biomass density. Density of the stand could also affect biomass production of the area. The more trees present the more biomass will be produced. In this study, the plantation forests have a spacing of 3m x 3m with 1,043 trees measured. Furthermore, the average tree biomass density varied with plantation age. Mean annual biomass value was found to be higher in older plantations.

Biomass Density and Amount of Carbon Stored

Natural forest. Total C content in the natural forest as shown in Table 3 was 149.4 t/ha. Total C stored in above and belowground biomass was 68.7 t/ ha and the remaining amount of 80.68 t/ha was stored in the soil. Soil C content of the area accounted for 54% of the total C stored. The findings were in agreement with other studies which reported that soil carbon could be about 30% or more of the biomass. However, since the area has just recovered from logging, the soil organic matter could also be in the recovery process. In addition, soil samples were taken from 0-30 cm depth which is the portion of the soil where higher disturbances occur.

Plantation forest. As reflected in Table 4, the total carbon content of an eight-year-old plantation was 125.82 t/ha of which 70% was from the soil carbon stored in the area. Soil carbon in plantation was higher than previous studied agroforestry systems. Castro (2000) reported only a total of 107.8 t/ ha of C in a five-year-old agroforestry farm in Nueva Viscaya where vegetation was dominated by *Gmelina arborea*. The soil can recover its soil organic carbon (SOC) in plantation forests. Lasco et al. (1999) reported that C density of *Gmelina* plantations in Leyte is 294.16 t/ha and of which, 27.4% are in the biomass and the rest are found in the soil. Plantation sites selected for this study were previously grassland and coconut plantation areas. The intensive cultivation prior to the establishment of the plantation explains why there was low soil C in the plantation area.

Results of this study show that C content of the natural forest was higher than the plantation forest. Carbon in biomass in natural forests contributed to a higher proportion of C content in this forest type. But in

terms of soil C, there was slight difference between the two forest types. This was because disturbance in the soil occurred prior to the establishment of plantation and the natural forest has been subjected to human activities in the past 15-25 years.

Table 3. Biomass density and amount of carbon stored in natural forest.

CARBON POOL	BIOMASS DENSITY (t/ha)	CARBON (%)	C CONTENT (t/ha)
Aboveground Component			
Trees	81.02	53.39	43.26
Leaf	2.84	40.00	1.14
Understorey	21.04	52.95	11.23
Herbs/Weeds	0.45	49.00	0.22
Litter	5.31	47.80	2.54
Subtotal			**58.39**
Below ground Component			
Roots	20.61	50.11	10.33
Soil		2.83	80.68
Total			**149.39**

Comparison of C content in natural and plantation forests. Results of this study showed that the amount of C differs between natural and plantation forests. Total C in the natural forest was 149.4 t/ha, a little higher compared to 125.8 t/ha in plantation forest. The natural forest in this case had just recovered from logging more or less 20 years ago with dominance of slow-growing trees. *Gmelina arborea* is a fast growing species but the eight-year-old plantation in this study was relatively young with trees mostly in lower diameter classes. In this case, the number of years after plantation establishment was almost doubled by the number of years that the natural forest developed after logging activity but they have a very slight difference in C content.

According to Muora-Costa (1996) the choice of species affects the potential to sequester C. *Gmelina arborea* and *Acacia mangium* are commonly used for reforestation projects. They accumulate biomass and C faster than slow growing species for the same period of time. Fast growing species have lower wood density and therefore contain less C stored in the wood as compared to slow growing trees. Another factor aside from the kind of species planted is the site quality prior to reforestation activities, which could also affect the stored carbon (Lugo and Brown, 1992; Marland and Marland, 1999).

Both forest types contain significant amounts of C. However, in plantation forests where trees are harvested at rotation age, the carbon in the form of carbon dioxide will be emitted back to the atmosphere depending on the forest product desired after harvest.

Table 4. Biomass density and amount of carbon stored in plantation forest.

CARBON POOL	BIOMASS DENSITY (t/ha)	CARBON (%)	C CONTENT (t/ha)
Aboveground Component			
Trees	56.38	53.08	29.93
Leaf	1.98	40.00	0.79
Herbage	1.36	49.27	0.67
Litter	6.41	49.35	3.16
Subtotal	**66.12**		
Below ground Component			
Roots	6.12	52.41	3.21
Soil		1.38	88.07
Total			**125.82**

Biomass Density and Amount of C Sequestered After One Production Period

Natural forest. Plot data obtained from the inventory were used for stem volume, biomass, and carbon projection for a 30-year cutting cycle for climatic type 4. It was assumed that all other forest components are constant after one cutting cycle (30 years) for natural forests or one rotation (15 years) for plantation.

Results showed that after 30 years, the total biomass density was 381.37 t/ha for natural forests and 369.9t/ha for plantation forests after 15 years (Table 5). In this case, estimated biomass density for both forest types were almost the same inspite of higher stem volume accumulated in plantation forest, which contributed a lot to total biomass density. For stem volume, plantation forests accumulated 753.3cu m/ha while only 566.04cu m/ha were obtained for natural forests. Data show that there was a slower stem volume accumulation in natural forest that resulted to lower stem biomass accumulation for 30 years. Average dbh in plantation forest was 28.59 cm and almost 40% of trees have dbh of 30 cm and above for the 989 trees sampled.

Lower stem biomass density in natural forests was also due to the less number of trees per hectare. For 15-year-old plantation forest, the mean annual biomass increase was 24.7 ton/ha compared to 12.71 t/ha for the 30-year-old natural forest. Increase in biomass density was attributed to the increase in stem volume. Hence, slow growing trees species in natural forest accumulate less volume even if they have higher density. Plantation species are faster growing but have lower density compared to trees grown in natural forest. Total C sequestered from natural forest was 280.4t/ha, more than 50% of which is derived from stem biomass and almost 30% of the total C came from the soil (Table 6). For 15-year-old plantation, total C sequestered was 239.4 t/ha. It is worth noting that there was a difference of 15 years in age between the two forest types. However, only a very small difference was observed in terms of the amount of C stored.

Table 5. Projected biomass density (t/ha) after one production period

FOREST COMPONENTS							
FOREST TYPE	Stem	Leaf	Understory	Herbs	Litter	Roots	TOTAL
Natural	322.64	11.32	21.04	0.45	5.31	20.61	**381.37**
Plantation	339.00	11.89		0.48	7.35	11.17	**369.90**

Table 6. Projected amount of carbon (t/ha) sequestered after one production period

CARBON POOL								
FOREST TYPE	Stem	Leaf	Understory	Herbs	Litter	Roots	Soil C	TOTAL
Natural	171	4.53	11.14	0.22	2.54	10.33	80.68	**280.44**
Plantation	186.90	4.76		0.24	3.59	5.81	38.00	**239.47**

Assumptions: All forest components are constant except C for stem volumes.

Value of C Sequestration Services

Valuing C benefits or C sequestration services of the forest is considered in discussing different mitigation options to combat global warming. Studies conducted in Asia, was done to obtain an estimate of the monetary value of C using benefits transfer method. The average value of a ton C is US$ 5.0, to be applied for both forest types. Results of the study showed that a one hectare secondary forest that serves as a watershed reserve has a current value of US$ 746.53 (₱41,832), higher than the value of an eight-year-old *Gmelina arborea* plantation, which is US$ 629.10 (₱ 35,229) due to higher amount of C stored (Table 7).

Table 7. Current amount of carbon stored and its monetary value

FOREST TYPE	C CONTENT (t/ha)	MONETARY VALUE (US$)
Natural Forest	**149.4**	**746.5**
Eight-year-old *Gmelina arborea* plantation	**125.8**	**629.1**

Values presented in Table 7 for both forest types were based on services rendered in capturing C alone without inclusion of other direct benefits that could be derived from both forest.

A higher amount of benefits is derived from natural forests due to its higher C content. If other benefits are considered, protecting the natural forest will still have a higher value. Consistent with the findings of Rivera (2003), short rotation plantation was the lowest with the assumption that C in trees will be released upon harvest.

C crediting

For this study, both types of CERs were used using different crediting periods. C valuation by C crediting assumes that no emissions and no positive leakage take place for both forest types. Since the natural forest

was logged in the late 1970s, it is assumed that the actual/current C stock estimates gathered in the study was about 30 years at the time of data measurement. *Gmelina arborea* plantation (15-year- old) trees were planted in 1985 for a 15-year rotation and it is assumed that the plantation will be renewed for another 15 years.

The current C stock and CERs for the natural forest as compared to the eight-year-old plantation under tCERs (fixed, 30 years) were 548 and 462, respectively (Table 8). Higher amount of CERs were derived from natural forest if the commitment period started 30 years ago.

Table 8. C stock and amount of CERs for natural and plantation forests

FOREST TYPE	TYPE of CER	CREDITING PERIOD	NO.OF YEARS	CREDITING LIFETIME	C STOCK	CER
1	2	3	4	5	6	7
Natural*	tCERs	Fixed	30	30	149.4	548
	lCERs	twice				
		Renewable	10	30 (Yr.10)	49.8	182
				(Yr.20)	99.6	365
				(Yr.30)	149.4	548
Natural**	tCERs	Fixed	30	30	280.4	1029
	lCERs	twice				
		Renewable	10	30 (Yr.10)	180.9	664
				(Yr.20)	223	818
				(Yr.30)	280.4	1029
Plantation*	tCERs	Fixed	30	30	125.8	462
	lCERs	twice				
		Renewable	10	30 (Yr.10)	83.9	307
				(Yr.20)	41.9	153
				(Yr.30)	125.8	461
Plantation**	tCERs	Fixed	30	30	239	877
	LCERs	twice				
		Renewable	10	30 (Yr.10)	176.9	649
				(Yr.20)	114.7	421
				(Yr.30)	239	877

The projected value of CERs using a 30-year cutting cycle in the natural forest was 1,029 CERs while for plantation forest, the estimate was 877 CERs on the assumption that the area will be planted again after 15 years.

For lCERs with a crediting lifetime of 30 years, and renewed every 10 years, plantation forest would have 421 CERs at year 20. This is because it was replanted after the first rotation.

Plantation forests have wider market opportunity especially if they are managed for a longer rotation. In this case, the government or private individual could gain monetary return, of US$ 4, 385.6 (US$ 5/ CER) for 877 CERs at the end of 30 years for tCERs with fixed crediting period. If a farmer opts for long-term CERs renewable every 10 years (30 yrs), the monetary value is higher in the first 10 years assuming that harvesting occurs after 15 years. The value of C in natural forest was 548 CERs and after 30 years it will be 1,029 CERs (US$ 5,145/ha) without intention to trade.

As expired tCERs can be replaced by new tCERs, it is most likely that a project developer will try to sell a succession of tCERs over the crediting period. Credit sales covering only one commitment period will increase transaction costs for both sides, and project risk is exclusively on the seller's side.

Since there is verification of CERs at a regular interval for long-tem CERs, developing countries engaged in AR projects could be at risk since uncertain things may happen during the production period that could affect the C sequestration process of the project and compensation will be affected since payment is done on the last year of the crediting period.

Expansion of plantations for C crediting opens an opportunity in developing countries as targets of CDM for AR projects. However, there is a risk for natural forests to be cleared and planted to give way to exotic species and this will have impacts on existing natural forests and biodiversity (Niesten et al., 2002).

CONCLUSIONS

1. Both natural and plantation forests contain a huge amount of C in the tree biomass and in the soil. Even if existing natural forests have slower growth, they are effective in storing C as long as the forests are adequately protected and managed.

2. *Gmelina arborea* plantations have faster growth and therefore accumulate C per unit of time faster in comparison with natural forest, provided plantations are established in suitable areas.

3. Biomass density and C accumulation capacities of different forest types vary depending on site quality, degree of disturbance, kind of species used, rotation period (in the case of plantations) and maintenance or management activities employed especially on natural forest.

4. There are monetary benefits for C sequestration services for natural and plantation forests. However, net realizable benefits should be compared to the cost incurred for the management of natural and plantation forests.

RECOMMENDATIONS

The following recommendations are forwarded:

1. Expansion of government reforestation projects especially in inadequately stocked or open areas can contribute significantly in sequestering atmospheric carbon. However, reforestation must be pursued with a clear understanding of the full costs and benefits of doing

it considering issues other than-carbon related concerns such as water, biodiversity, soil conservation and community welfare.

2. The huge amount of C captured and stored by natural forest could be used as additional justification for the maintenance and protection of the natural forest in the country.
3. C sequestration potential should be used as one of the bases for evaluating alternative uses of forestlands particularly those with remaining forest cover.
4. C trading /market may encourage private landowners and local communities to increase their involvement in forest plantation development. This should be complemented with appropriate incentives and reduction of transaction costs for getting into plantation development.
5. If the government, private individuals or corporations invest in tree plantations, the target product should be evaluated and studied given the concerns on carbon dioxide emissions. Reforestation species that are used primarily for furniture and construction purposes should be favored.
6. Creation of a database and other management decision support systems to improve success of plantation development and increase effectiveness of monitoring efforts should be given high priority.
7. Studies should be pursued to determine the costs and benefits of the management of plantation and natural forest for C sequestration. This will improve the current understanding of the feasibility of participation in C market.

LITERATURE CITED

BROWN, IF, DC NEPSTAD, IO PIRES, LM. LUZ and AS ALECHANDRE.1992. Carbon Storage and Land–Use in Extractive Reserves, Acre, Brazil. Environmental Conservation. 19: 307-315.

BROWN, S. 2003. Carbon Markets and Financing for Projects. Paper Presented during the FORUM on CDM in the Philippines: Sustainable Development Opportunities through Community-Based Forestry Projects. Development Bank of the Philippines, Makati City . April 7, 2003.

BROWN, S. 1997. Estimating Biomass and Biomass Change of Tropical Forests. A primer. FAO Forestry Paper Number 134.

BROWN, S and AE LUGO.1990. Tropical Secondary Forests. Ecol. 6:1-32.

BROWN, S, AJ GILLESPIE and AE LUGO.1991. Biomass of Tropical Forests of South and Southeast Asia. Can. J For Res. 21: 111-117.

CASTRO, L. 2000. Carbon Storage Potential of an Agroforestry Farm in Bayombong, Nueva Viscaya, Philippines. MS Thesis. UP Los Baños.

GUILLERMO, IQ. 1998. CO2 Sequestration Potentials of a Secondary Forest Ecosystem in Makiling Forest Reserve, Philippines. Undergraduate Thesis. UP Los Baños.

Intergovernmental Panel for Climate Change (IPCC). 2000. Land-use. And Land-use Change in Forestry. World Meteorological Organization and United Nations Environmental Program. The Cambridge University Press.

LASCO, RD, JS SALES, T ARNUEVO, IQ GUILLERMO, AC DE JESUS, R MEDRANO, OF BAJAR AND CV MENDOZA. 1999. Carbon Dioxide (CO2) Storage and Sequestration of Land Cover in Leyte Geothermal Reservation. Environmental Forestry Program, UPLB-CFNR, College, Laguna, Philippines.

LUGO, AE, D WANG and FH BORMANN. 1990. A Comparative Analysis of Biomass Production in Five Tropical Tree Species. Forest Ecology and Management. 31: 153-166.

LUGO, AE and S. BROWN. 1992. Tropical Forest as Sink of Atmospheric Carbon. Forest Ecology and Management. 54: 239-255.

MACNALLY, R. and MOHD-SHAHWAHID H.O. 2001. An Economic Valuation of the Terrestrial and Marine Resources of Samoa http://wwf.org.uk/filelibrary/pdf/econ_Samoa.pdf

MARLAND, G and S MARLAND. 1999. Should we Store C in Trees? Water, Air and Soil Pollution, 64: 181-195.

MICHAELOWA, A and T KOCH. 2001. Glossary of International Climate Policy Terms. http://www.de/Publikationen/Report2001/Report208.pdf.

MOURA-COSTA, P. 1996. Tropical Forestry Practices for C Sequestration. *In*, A Zchulte and D. Schone (eds.). Dipterocarp Forest Ecosystems: Towards Forestry Management. Singapore: World Scientific pp:308-334.

MURDIYARSO, D. and UR WASRIN. 1995. Estimating Land Use Change and C Release from Tropical Forests Conversion Using Remote Sensing Technique. J. Biogeography 22: 715-721.

NEGI, JD, SC SHARMA and DC SHARMA. 1988. Comparative Assessment of Methods for Estimating Biomass and Forest Ecosystem. Indian Forester.

NIESTEN, E, PC FRUMHOFF, M MANION and JJ HARDNER. 2002. Designing a Carbon Market that Protects Forests in Developing Countries. http://www.ucsusa.org/documents/carbons.pdf

RIVERA, MCN. 2003. Comparative Analysis of Costs and Benefits of Potential Climate Change in Mitigation Options in the Philippine Forestry Sector. Ph.D. Dissertation. UP Los Baños.

ROCHOW, JJ. 1973. Estimates of Aboveground Biomass and Primary Productivity in a Missouri Forest. Journal of Ecology. 657-577. November 1973.

SEDJO, PA and AM SOLOMON. 1989. Climate and forest. *In*: Proceedings Workshop in Greenhouse Warming; Abatement and Adaptation, Washington D.C. June 14-15, 1989.

TANDUG, LM. 1992. Development of Volume Equations in the Philippines. Canopy International. Vol. 18 No.1

URIARTE, MT and FD VIRTUCIO. 1999. Growth and Yield of Residual Forests in the Philippines. Philippine Lumberman. Nov-Dec.

ZAMORA. DS. 1999. CO2 Storage Potentials of Multistorey Agroforestry in Mt. Makiling. Graduate Thesis. UP Los Baños.

A Study on Conservation of Plant Diversity in Mangrove Forests in Trat Province in Thailand

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INTRODUCTION

Mangrove forest in Nong Khan Song District, Muang, Trat Province is a conservation forest, having an area of approximately 3,500 rais, and located on the east coast of Thailand. Leaders of the community do wish to conserve the forest for the younger generations. Local people want to gain some benefits from this area but they do not want to damage the forest. People have exerted some efforts to conserve and maintain its beauty but they lack the management know-how in maintaining the value of the mangrove forest. It is for this reason that researchers from Rambhai Barni Rajabhat University conducted participatory action research (PAR) in the area involving local people and the leaders of the community. The latter need the basic knowledge to maintain sustainability of the mangrove ecosystem while at the same time enjoying income benefits from it. The area is also seen as having potential for ecotourism in the east of Thailand.

Objectives of the study

The general purpose of the study was to gather local people's knowledge on the conservation of plant diversity in mangrove forests in Pak Klong Bang Pra, Koh Chao and Koh Loi, Nong Khan Song District, Muang, Trat Province. Specifically, the study was aimed to:

1. Gather management know-how as to the conservation of the mangrove forests in the context of the local people;

2. Study the plant diversity in the area from which to base some conservation techniques;

3. Encourage responsible use among local people by helping them conserve and sustain the forest;

4. Establish Mangrove Forest Education Center for primary school children in the research area; and

5. Strengthen the coordination among primary school administrators, the local community and concerned organizations in an attempt to improve the local environment and natural resource of the research area.

Significance of the Study

Efforts at conserving the plant diversity in the Nong Khan Song District will be strengthened and made more successful by seeking the participation of the members of the community. The participation on the other hand of the latter will be better realized by recognizing their efforts. Local people do have indigenous knowledge in conserving and protecting the areas that can be tapped to the advantage of all stakeholders. Furthermore indigenous knowledge can be used to complement with existing scientific techniques which will then be applied in the establishment of the Mangrove Forest Education Center. The Center will then serve as laboratory for students studying ecology and conservation techniques for mangrove forest areas.

Methodology

Participatory Action Research (PAR) was employed in the study. This is in connection with the Rambhai Barni Rajabhat University's effort to integrate environmental conservation into their teaching.

1. Data gathering from the Local Community

   Researchers and students from Rambhai Barni Rajabhat University who reside in Nong Khan Song District interviewed some local leaders and laypersons to gather indigenous knowledge techniques on mangrove conservation in the context of the local community. Researchers and stakeholders also conducted a seminar to exchange views, opinions and knowledge on utilization and value of mangrove forests.

2. Data Collection on Plant Diversity

   Students who were studying ecosystem of mangrove forest and its surrounding environment gathered data as to the kind of plants growing in the area and their botanical characteristics and scientific names. These were done by laying transect lines on the seashore and gathering data from 170 plots.

3. Setting up of Plan for Mangrove Forest Conservation

   Collaboration between researchers and teachers in Wat Nong Khan Song School was established to formulate lessons on mangrove conservation for pupils in Prathom Suksa 4-6, Primary School.

   Activities on mangrove conservation for pupils were organized. These were:

   - Activity 1: Replanting for mangrove forest.
   - Activity 2: Mangrove forest conservation camp
   - Activity 3: Study on successful mangrove forests in other areas.

4. Establishment of Mangrove Forest Education Center at Wat Nong Khan Song School

Results

1. Data Gathering form the Local Community

Data and knowledge gathered from the community include the need for replanting of mangroves and medicinal plants growing in the area. It was also learned that food can be derived from planting mangroves, and that there are benefits of the mangrove forest to fishing. It was also learned from the community that there are other products and other dyes that can also be derived from mangrove trees. These include hats, tannins extracted from mangrove bark, leaves that are dried and used as tea, and young mangrove leaves as substitute of tobacco for smoking.

2. Data Collection on Plant Diversity

This part of the study identified many species and families of mangrove trees. These are as shown in Table 1.

Table 1. Kinds of Plant and their Frequency

No.	Scientific name	Family	Number of plots	Frequency (%)
1	*Drynaria gurcifolia*	**FILICINAE**	10	5.88
2	*Finlaysonia maritime* Black	**ASCLEPIADACEAE**	8	4.71
3	*Dendropthoe pentandra*	**LORANTHAEAE**	2	1.18
4	*Drymoglossum piloseloides*	**FILICINAE**	4	2.35
5	*Cirrhopetalum lepidum* (Blume) Schltr.	**ORCHIDACEAE**	2	1.18
6	*Dendrobium crumenatum* Sw.	**ORCHIDACEAE**	7	4.12
7	*Cymbidium finlaysonianum* Lindl.	**ORCHIDACEAE**	2	1.18
8	*Aerides falcate* Lindl.	**ORCHIDACEAE**	1	0.59
9	*Luisia sp.*	**ORCHIDACEAE**	1	0.59
10	*Dendrobium bilobulatum* Seidenf.	**ORCHIDACEAE**	2	1.18
11	*Rhizophora apiculata*	**RHIZOPHORACEAE**	145	85.29
12	*Rhizophora mucronata* Poir.	**RHIZOPHORACEAE**	30	17.65
13	*Asplenium nidus*	**FILICINAE**	2	1.18
14	*Pluchea indica* Less.	**COMPOSITAE**	6	3.53
15	*Nypa fruticans* Wurmb.	**PALMAE**	5	2.94
16	*Premna obtusifolia* R. Br.	**VERBENACEAE**	1	0.59
17	*Xylocarpus granatum* Koen.	**MELIACEAE**	84	49.41
18	*Xylocarpus moluccensis* Koen	**MELIACEAE**	11	6.47
19	*Excoecaria agallocha* L.	**EUPHORBIACEAE**	29	17.06
20	*Derris trifoliate* Lour.	**LEGUMINOSAE**	15	8.82

21	*Bruguiera cylindrical* Bl.	RHIZOPHORACEAE	2	1.18
22	*Parthenocissus vitacea*	VITACEAE	1	0.59
23	*Caesalpinia crista* L.	LEGUMINOSAE	1	0.59
24	*Hoya lacunosa*	ASCLEPIADACEAE	8	4.71
25	*Wedelia biflora* (L.) DC.	COMPOSITAE	3	1.76
26	*Intsia bijuga* (Colebr.) O. Ktze	LEGUMINOSAE	12	7.06
27	*Bruguiera sexangula* Poir.	RHIZOPHRACEAE	27	15.88
28	*Bruguiera gymnorrhiza* (L.) Savigny.	RHIZOPHRACEAE	34	20.00
29	*Phoenix paludosa* Roxb.	PALMAE	6	3.53
30	*Hibiscus tiliaceus* L.	MALVACEAE	2	1.18
31	*Acrostichum aureum* L.	PTERIDACEAE	49	28.82
32	*Acrostichum speciosum* Willd.	PTERIDACEAE	35	20.59
33	*Ceriops decandra* Ding Hou	RHIZOPHORACEAE	4	2.35
34	*Ceriops tagal* (Perr.) C. B. Rob.	RHIZOPHORACEAE	31	18.23
35	*Drynaria microphylla*	FILICINAE	17	10.00
36	*Lumnitzera littorea* Voigt.	COMBRETACEAE	38	22.35
37	*Lumnitzera racemosa* Willd.	COMBRETACEAE	5	2.94
38	*Sonneratia caseolaris* (L.) Engl.	SONNERATIACEAE	5	2.94
39	*Sonneratia ovata* Back	SONNERATIACEAE	2	1.18
40	*Sonneratia griffithii* Kurz	SONNERATIACEAE	1	0.59
41	*Avicennia alba* Bl.	AVICENNIACEAE	29	17.06

42	*Avicennia officinalis* L.	AVICENNIACEAE	4	2.35
43	*Dalbergia candenatensis*	LEGUMINOSAE	2	1.18
44	*Clerodendrum inerme* (L.) Gaertner	LEGUMINOSAE	4	2.35
45	*Flagellaria indica L.*	FLAGELLARIACEAE	3	1.76
46	*Hydrophytum formicaum* Jack.	MYRSINACEAE	1	0.59
47	*Acanthus ebracteatus* Vahl.	ACANTHACEAE	2	1.18
48	*Heritiera littoralis* Ait.	STERCULIACEAE	18	10.59

*** percent of frequency = $\frac{\text{Number of plots}}{\text{Total plots}} \times 100$

Table 2. Density of Mangrove Trees

No.	Scientific name	Density					
		Tree		Sapling		Seedling	
		plant/plot	plant/rai	plant/plot	plant/rai	plant/plot	plant/rai
1	*Rhizophora apiculata*	7.46	119.36	4.12	65.92	0.39	624
2	*Rhizophora mucronata* Poir.	0.97	15.52	0.55	8.80	0.02	32
3	*Xylocarpus granatum* Koen.	2.42	38.72	1.67	26.72	0.05	80

4	*Xylocarpus moluccensis* Koen.	0.29	4.64	0.16	2.56	0.01	16
5	*Excoecaria agallocha* L.	0.38	6.08	0.19	3.04	0.01	16
6	*Bruguiera cylindrical* Bl.	0.02	0.32	0	0	0	0
7	*Intsia bijuga* (Colebr.) O. Ktze	0.09	1.44	0.06	0.96	0	0
8	*Bruguiera sexangula* Poir.	0.20	3.20	0.24	3.84	0.01	16
9	*Bruguiera gymnorhiza* (L.) Savigny.	0.24	3.84	0.27	4.32	0	0
10	*Hibiscus tiliaceus* L.	0.01	0.16	0.01	0.16	0	0
11	*Ceriops decandra* Ding Hou	0.07	1.12	0	0	0	0
12	*Ceriops tagal* (Perr.) C. B. Rob.	1.13	18.08	1.38	22.08	0.68	1088
13	*Lumnitzera littorea* Voigt.	0.58	9.28	0.26	4.16	0.29	464
14	*Lumnitzera racemosa* Willd.	0.03	0.48	0.01	0.16	0	0

15	*Sonneratia caseolaris* (L.) Engl.	0.09	1.44	0.02	0.32	0	0
16	*Sonneratia ovata* Back	0.02	0.32	0	0	0	0
17	*Sonneratia griffithii* Kurz	0.02	0.32	0	0	0	0
18	*Avicennia alba* Bl.	0.79	12.64	0.36	5.76	0.01	16
19	*Avicennia officinalis* L.	0.16	2.56	0.20	3.2	0.02	32
20	*Heritiera littoralis* Ait.	0.31	4.96	0.13	2.08	0.03	48

Seedling = perimeter of stem is less than 1 cm.
Sapling = perimeter of stem is less than 4 cm. but longer than 1 cm.
Tree = perimeter of stem is longer than 4 cm.

*** 1 plot for tree and sapling = 100 m^2
*** 1 plot for seedling = 1 m^2
*** rai is unit of area, 2.50 rais = 1 acre , 6.25 rais = 1 hectare

3. Setting-up of Plan for Mangrove Forest Conservation

Wat Nong Khan Song School is a primary school which had incorporated lessons on mangrove conservation for pupils in Prathom Suksa 4-6. Their lessons are based on observations and studies made on mangrove forests at Pak Klong Bang Pra, Kho Chao and Kho Loi, Nong Khan Song District.

Interests of pupils in mangrove conservation especially that of Wat Nong Khan Song School and Wat Lam Hin School, were developed and stimulated by organizing activities like camping. The students from Rhambhai Barni Rajabhat University were the leaders and demonstrators in this activity.

Mangrove forest observation and sight- seeing activities were also organized for community leaders at the mangrove forest conservation project of the King in Chanthburi Province.

4. Establishment of Mangrove Forest Education Center at Wat Nong Khan Song School

The teachers, local people, pupils and researchers collaborated to establish Mangrove Forest Education Center. Grown in the Center are species like *Rhizophora spp.,Lumnitzera spp., Sonneratia sp. Nypa sp. Bruguiera spp.* These are species that can be grown as ornamental plants.

Conclusion and Discussion

This study found that mangrove forests in Pak Klong Bang Pra, Koh Chao, Koh Loi are successful ecosystems composed of 48 species, and 21 families of plants and mangrove trees grown in the area. These could be divided into 3 groups: epiphyte, herbaceous plants and trees. A total of 14 epiphytes were found which included 6 orchids. There were also found 14 herbaceous plants and 20 trees. (Table 1). Plant density of saplings and seedlings were found to be lower than the trees. There therefore is a need for the community to culture and replant seedlings because in time, natural propagation will be decreased.

Conservation efforts for the mangrove forest ecosystem can be done in four areas. One is in the area of education. Here, there needs an establishment of knowledge center for the community, and conduct of basic research to help solve the problems in their community. Second is in the area of economic development. Ecotourism, local fisheries and propagation of plants from the mangrove forest can be done. Third is in the area of social science like establishment of local organizations, setting-up of policy to protect the mangrove forest, and management of garbage. Fourth is in the area of social marketing where promotion of mangrove conservation efforts can be enhanced through various media like the electronic media, print media, exhibits and local festivals.

Impact of the study

1. Impact to the community

1.1 A remarkable level of unity among community members was obseved. Given leadership from the government, the local people will be willing and ready to cooperate.

1.2 The local people expressed willingness to collaborate with any one wishing to study or conduct a research on this natural resource. They view research studies and projects with the government as necessary to improve their place.

1.3 The people showed enhanced awareness on the importance of mangroves. They were familiar with the use of the plants and they understood how and why they need to conserve them.

1.4 The local people showed respect for local wisdom. They were interested to use them for commercial purposes to generate income for their family and the community.

2. Impact to the students

The students had a good experience in learning by doing by going out and having hands-on training outside the classroom.

References

Aksornkoae, S. 1998. Mangroves: Ecology and management Kasetsart University. Bangkok.

Aksornkoae, S., and R. Tokrisna, 2004. Overview of shrimp farming and mangrove loss in Thailand, in E.B. Barbier and S. Sathirathai (eds.)Shrimp Farming and mangrove loss in Thailand.

Barbier, E.B. 2003. Habitat-fishery linkages and mangrove loss in Thailand. Contemporary Economic Policy, 21 (1), 59-77.

Botkin, D. and E. Keller. 2003. Environmental Science, John Wiley & Sons.

Edward B. Barbier. 2007. Valuing ecosystem services as productive inputs. Available in http://www.blackwell synergy.com/doi/ref/10.1111/j.1468-0327.2007.00174.x

Eganathan,P. 2004. Conservation and sustainable utilization of coastal mangrove forest with community participation. Knowledge marketplace reports, 17-25 November, The 3rd IUCN World Conservation Congress, Bangkok, Thailand.

Ewel,K.C., Twilley,R.R. & Ong , J.E. 1998. Different kinds of mangrove forests provide different goods and services. Global ecology and Biogeography Letters 7, 83-94.

Huu Nghia, Nguyen. 2007. Mangrove forest conservation and development planning in Nghe An-Vietnam. Available in http:// www.Gisdevelopment.net/application/environment/ffm/mangrove.htm

Saenger, Peter. 2002. Mangrove ecology, silviculture and conservation. Kluwer Academic Publishers, Dordrecht.

Valie, I., J.L.Bowen and J.K. York.2001. Mangrove forests:One of the world's threatened major tropical environments, Bio Science, 51(10), 807-815.

Agroecosystems Analysis for the Sustainable Development of Lake Buhi

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INTRODUCTION

Lake Buhi is a very essential natural resource being the home to the smallest fish in the world, Sinarapan (*Mistichthys luzonenzis)*. The population of this smallest fish, also known as Tabios, is very much endangered with the massive production of introduced fish specie, Tilapia, which is being grown on a commercial scale in the Lake.

The massive denudation of the surrounding watershed also pose a threat to tabios' existence. Siltation due to erosion of surrounding areas is disastrous to the biodiversity in the Lake, including "Sinarapan". Knowing the current agro-ecological practices in the Lake and its surrounding areas can give information on the rate of damage that siltation poses on the Lake. This then will have to be communicated to the stakeholders (women and men upland dwellers, farmers and IPs) so the latter can identify and work out some coping mechanisms to minimize its impact to the lake biodiversity.

An inventory of the commercial fish cages and other industrial activities going on in the Lake was also deemed very important. Essentially, this activity gave information on whether the principle of carrying capacity of a given resource was considered. Knowing this can prevent overuse, pollution and damage to this important resource. This can also ensure sustainable use of the Lake for the maintenance and survival of its indigenous biodiversity, including "Sinarapan or tabios".

The analysis of the local ordinances developed by the Local Government Unit (LGU) of Buhi for the utilization and management of the Lake and its surrounding environ was also carried out to determine whether the ordinances are resource friendly and are favorable to the sustainable use of the Lake.

Finally, the determination of possible sites, which can be developed into fish sanctuary of "Sinarapan or tabios", was made to provide it an additional safe breeding and production ground. Although there is an

existing 'Sinarapan' sanctuary in the site, the local officials feel that the site was very inadequate to ensure sustainable population of the fish in Buhi Lake.

OBJECTIVES OF THE STUDY

This research was undertaken to analyze the agro-ecological systems within the Lake and its surroundings. The following are the specific objectives:

1. Determine the agro-ecological practices in the buffer zone and agricultural areas surrounding and within the Lake and their perceived effects on the Lake and on women and men upland dwellers / farmers and indigenous peoples;

2. Generate awareness and identify coping mechanisms to reduce if not counter the perceived effects of the agro-ecological practices among the upland dwellers / farmers and indigenous peoples across gender;

3. Come up with an inventory of commercial fish cages and other industrial uses of the Lake;

4. Analyze the present local ordinances related to the agro-ecological system's and Lake use and their effect on the Lake itself; and

5. Determine possible sites to be developed into sanctuaries of tabios to ensure sustainable population of the smallest fish in the world.

METHODOLOGY

A combination of traditional and contemporary research methodologies were used to generate desired information, which include community survey, PRA, focused group discussion (FGD), transect walk and mapping, SWOT Analysis, IEC for creating awareness and developing participatory skills, actual inventory of fish cages, and the more technical methods of determining the bio-physico-chemical properties of the lake waters, sediments and phytoplanktons, including infiltration rates and stream flow.

Agro-ecological systems analysis was done through a triangulation method involving area survey and field observations, field interview of women and men upland dwellers, fisherfolks and IPs living in surrounding areas of Lake Buhi and focused group discussions (FGDs) in the surrounding upland barangays. These were conducted to bring to light current practices, analyze such practices in terms of its impact to the Lake and with them and

identify coping mechanisms to minimize the impact of identified agro-ecological practices on the Lake. To address the problem of poor agro-ecological practices in the uplands, a training on sloping land management, among others, were conducted for the women and men upland dwellers and IPs. It aimed to improve their current agro-ecological practices and to minimize soil erosion and siltation of the Lake. IEC materials were also developed in support to environmental advocacy and to enhance understanding of the upland dwellers and IPs on sloping land management.

Actual inventory of commercial tilapia cages and the rate of production, including production technologies were made through actual count and interview of cage owners and use of secondary data of registered cage owners with the LGU and the Department of Agriculture / Fisheries (DA/F). Some parameters to determine fish cage area vis-à-vis carrying capacity of the Lake were studied; and water, sediments and phytoplankton analyses were also made. Interviews about the phenomenal changes observed in the Lake in the past years and their frequency of occurrence were also conducted.

Local ordinances were studied using secondary data from the LGU. Their implementation strategies were also analyzed. The process of analysis was made through an FGD cum workshop. Using the SWOT analysis, the strengths, weaknesses, opportunities and threats were identified in each of the local ordinance passed related to the Lake's use and maintenance. A workshop focused on how to address the weaknesses and how such weaknesses can be converted to opportunities was done. On the threats, analysis was made on how to minimize them and on how to cushion their impact on the Lake and its environs.

Actual observation and analysis of the lakelets in the surrounding watershed was made to identify the potential areas to be developed as fish sanctuary of tabios.

The Study Site

The study covered the barangays surrounding Buhi Lake (Fig. 1). The seven upland barangays included in the study were Salvacion, Cabatuan, Tambo, Sta. Cruz, Ipil, Iraya and Ibayugan. In terms of systems boundaries, these seven barangays are within the watershed ecosystem. The three other barangays studied, representing the lowland ecosystem, are those situated within the Poblacion area, which are barangays Sta. Clara, San Buenaventura and Sta. Elena. Barangays San Ramon and De la Fe, where the lakelets are found, were also included in the study site because of the need to identify potential sites to be developed as sinarapan sanctuary. Figure 2 shows the map of the upland barangays within the Buhi watershed and Barangays San Ramon and De la Fe which are hosts to several lakelets in Buhi that can be developed into Sinarapan sanctuary.

The Study Population and Sampling of Respondents

There are 25,796 individuals living in the 10 barangays surrounding Lake Buhi (Table 2). Of this number, around 360 participants were invited to attend the FGDs conducted with a minimum of 30 participants per barangay constituting the Barangay officials, upland farmers, fish cage operators, IPs and rural women. Identification and invitation of participants were made by the Barangay Captain and the Barangay Secretary. The FGD for local officials and representatives of relevant agencies was also attended by some Sangguniang Bayan (SB) members, representatives from the Environmental Management Service (EMS), Department of Education (DepEd), Department of Agriculture (DA), Bureau of Fisheries and Aquatic Resources (BFAR), Women Sector, Religious Sector, NGO, Fisherfolks, and Farmers' Sector, among others. Aside from the FDG participants who were involved in the study, some other Barangay constituents were purposively sampled for the conduct of community survey to represent the upland farmers and IP group, fisherfolks and fish cage operators / owners, across gender. The proportional allocation technique was used to generate responses from at least 50% of the population of upland farmers, IPs, Fish Cage Operators and residents along the lakeshore (Table 1).

Instrumentation

Based on the requirements of objective 1 and 2 of this study, three sets of interview questionnaires were developed to generate information from the target respondents. The instrument included questions that would get data on the socio-economic profile of the respondents, production profile across gender, farming / fishing systems, technologies used in farming / fishing, sources of technologies used, perception questions to generate information on the effects of their practices on the lake resources and its environs, and on sustainability mechanisms.

The questionnaires were peer-reviewed by the research team and pre-tested to identify questions that may not be able to generate desired responses, after which, revisions were made before actual interview.

On the more technical side of the study, the bio- physico-chemical parameters were used as tools in the analysis of the properties identified. Standard procedures for measuring infiltration rates and stream flow of water from tributaries were also followed.

Data Gathering and Institutionalization Mechanism

Primary data necessary for the research were generated through FGDs and face to face interview with the respondents. Transect walk was also conducted to triangulate results of the community survey and FGDs, and to observe current farming practices and the existing flora and fauna in the watershed. Water, sediments and phytoplankton sampling were made

for laboratory analysis with the aid of a GPS for mapping out collection sites. Actual inventory of fish cages was also made since this information could not be generated from secondary data and from the interview with identified respondents. A training on Technology of Participation (ToP) for Agroecosystems Analysis for Sustainable Development of Lake Buhi was conducted to bring together all relevant sectors and stakeholders and train them in using the ToP as facilitation tool for generating people's participation. This was with special focus on analyzing Buhi agroecosystems for its sustainable development.

Secondary data from various relevant sources were also gathered, particularly the Municipal Socio-Economic and Physical Profile, Barangay profiles, ordinances, fish operators registry and other necessary data from relevant agencies operating in Buhi.

Before all research and development related activities started, however, an audience with the Local Chief Executive was made by the research team and some graduate students. Rapid rural appraisal of the study site followed. Strong coordination with the Barangay officials was developed by the research staff to ensure local participation during the conduct of FGDs and community surveys. Also, to ensure institutionalization of the research activities at the LGU for environmental conservation, including that of sinarapan, the research team participated in all meetings and activities called for by the EMS and the Sinarapan Sanctuary Management and Development Council (SSMDC).

Data Analysis

Data were analyzed using descriptive and qualitative tools following the process framework for agro-ecosystems analysis. The socio-economic and gender data were analyzed using frequency counts, percentages, means, modal values and ranks. Water, sediments and phytoplankton analyses were made through laboratory analysis and results were compared with standards. Other data gathered were analyzed through qualitative means.

Framework of the Study

The agro-ecological systems framework of Conway (1986), supplemented by the Technology of Participation Framework by MToP, USA were used in this study.

The Agroecosystems Analysis for Development (AAD) as developed by Conway (1986) was modified and used as the major methodology in this study. It is a participatory research approach, which uses systems analysis to define behavior of an area or natural resource in the context of relationships and interactions of the assemblage of elements contained within the boundaries of a given area. It is also a process that builds a

common understanding and ground for action among major stakeholders given the state and conditions of an area or natural resource.

Conway (1986) defines an ***agroecosystems*** as a complex agro-socio-economic ecological system. Basically, an agroecosystem is a natural ecological system such as watershed, forests, or lakes transformed for the purpose of food, fiber or energy production. The process of transformation involves human interaction with the natural processes to produce a specific product such as rice, fish or electric power. Consequently, the extent and magnitude of the processes of transformation and interaction produces a distinct behavior of the natural ecological system. The behavior of the natural ecological system to most extent defines the level of production of outputs (e.g. water, timber, fish) of the system. To provide such understanding of the natural ecological system as modified by human intervention, Conway (1986) proposed that relationships and patterns of resource use be identified as bases to assess systems performance in producing outputs. This process is called the ***pattern analysis*** where spatial relationships, temporal dimensions, flow patterns and decision-making processes are identified and analyzed.

The patterns and trends as revealed become the bases for a current reality assessment that provided an articulation of insights and perceptions of stakeholders.

Conway and Sajise (1986) also indicated that in order to make the analysis meaningful, a systems property assessment should be made to measure systems performance. This was done with the identification of positive and negative factors affecting systems performance. Four systems properties were identified as parameters for assessment: ***productivity, stability, sustainability and equitability***.

To further discern the interrelationships and assess systems performance, the Buhi agroecosystems was clustered into three eco-zones: (1) watersheds and forest/ upland areas, (2) the Buhi Lake and river systems, and (3) the lowlands and the peri-urban areas.

The unit of analysis was two-fold: household and watershed levels. In all these analytical processes, it was emphasized that the participation of local stakeholders is critical and that the activity should be both a learning and consensus building exercise. To meet these requirements, the Technology of Participation (ToP) was used as tool to complement and enhance the agroecosystems analysis. ToP is a facilitation tool that elicits stakeholders' participation in understanding current realities in the Lake and in the analysis of trends and patterns in resource use. Usually, the ToP is a tool used in local governance projects to systematically capture participants' insights/inputs and cluster such in themes and establish consensus.

STUDY RESULTS AND DISCUSSIONS

A.1.a Socio-economic Profile of Respondent Farmers and Fisherfolks

Women and men farmers were generally old (51 years and above) while the fisherfolks were in the middle age (36-50 years) most of whom were married. The fisherfolks were better educated with majority having attained secondary level of education compared to the farmers who have generally attained up to elementary level only. There were also a number of college graduates among the fisherfolks indicating that the fishing business requires some degree of skill and competence in entrepreneurship which they can get through formal education. Income of fisherfolks was generally higher than those of the farmers. Among the farmer groups, the upland farmers had higher income; women IPs reported the lowest income among the study groups. Both groups reported to have long experience (more than 16 years) in their occupation, although quite a big number of fisherfolks were new (less than 5 years) in the business.

1.b Farming Practices of Respondent Farmers and Fisherfolks

On agro-ecological practices, findings showed that the farmers including the IPs were adopting three major farming systems, which were integrated, multiple and monocropping systems depending on crops grown on mountain slopes. They practically planted all kinds of crops for home consumption or for the market. In general, monocropping was used in lower elevations for rice and corn production. Mid-hilly lands were planted to various crops including plantation crops intercropped with some banana, abaca, rootcrops and vegetables. High elevation lands were planted with trees but IPs used to do kaingin and slash and burn activities for root crop and fruit production. Animal production was usually integrated with crops, particularly poultry (native chicken and ducks), and carabao was grown as source of labor. They practice continuous cultivation of sloping lands for crop production and some, particularly the farmers in the lakeside used inorganic fertilizers and pesticides to improve soil condition and control pests. IPs do not use fertilizers and pesticides. There were also a number of commercial scale growers of swine along the Lakes' shoreline that drained their wastes into the Lake. Households along lakeside were also reported to be draining their septic and other domestic wastes in the Lake.

Inland fish culture had also grown wide in the Lake covering around 70 – 80 percent of its surface. Fish cage operators were overstocking their fishcages requiring the use of more commercial feeds. In one cropping cycle, with the present inventory of fishcages numbering 15,597 cages and a stocking density of around 2,500 tilapia fingerlings per cage of 100m2, around 2,837.5 tons of feeds were used per production cycle. This became a quick source of high nutrient loading in the Lake. Majority of the fish cage operators were operating on small scale. Only few were large scale operators, most of whom were outsiders using dummy operators in Buhi.

1.c Gender Roles in Farming and Inland Fishing

Both women and men farmers and fisherfolks were performing similar work in their respective occupation. For the farmer groups, results showed that tasks in the farm were becoming a shared responsibility of women and men, which means that women can also perform tasks that men do, except for fertilizer / pesticide application, which is mainly men's task. Young boys also performed tasks in the farm, but not much of the girls. Women were in-charge of marketing their farm products and buying their household needs. Among the fisherfolks, women and men also shared responsibility, just like the farmers. However, women's participation were limited to tasks requiring much care and attention like fish stocking, transferring of fish to growing pens, and caring of fingerlings. Young girls' involvement in the fishing activities was mainly in the care and maintenance of fish cages. Marketing is a shared task of women and men.

Comparing the participation of women and men in agriculture and fishery, it was noted that agricultural or farming activities are more women-friendly than fishing activities. Farming seemed to be less risky for women than fishing. Only those activities in fishing that require vital care and attention are delegated to women; high risks activities are done by men. Similarly, high risk activities in farming, like application of fertilizers and pesticides were men's job.

1.d Soil and Water Conservation Practices of Upland Farmers and Fisherfolks and Effects on the Bio-Physico-Chemical Properties of Lake Buhi

Very few of the farmers had ever practiced soil and water conservation measures. Among those practicing, their most common practice were the use of soil barriers, bench terracing and mulching. Reforestation, riprapping and planting of vetiver as hedgerows were also revealed during FGDs to be done in some upland barangays of Buhi. The perceived effects of their non-adoption of soil and water conservation practices include increase in water hyacinth, decrease in fish biodiversity and disappearance of sinarapan (highly perceived); algal bloom and lake degradation (moderately perceived); and chemical pollution, erosion, shallowing of lake, siltation and sedimentation and flooding (least perceived).

Validation through the physico-chemical properties indicated that lake waters have high total suspended solids (TSS) resulting to turbid waters; shallow depth; acidic pH; high chemical oxygen demand (COD) due to high organic matter; and ammoniacal oxygen, nitrate nitrogen and phosphates are at toxic levels. The depth of sediments across the Lake was from 1.14 to 2.5 m, clay to clayey in texture, highly acidic, with high organic matter (OM) content but with low nitrogen, phosphorus and potassium (NPK) content. These physico-chemical properties of the water and sediments from the tributaries and Lake were above the standards for class C lake

indicating that Lake Buhi is now in the stage of eutrophication. On the Lake's biological properties, there were 26 species of phytoplanktons identified, with three polluted water algae and three odor algae, which means that there are enough phytoplanktons for the fish biodiversity. However, the presence of polluted and odor algae indicated that the lake water is now polluted and is emitting foul odor from decaying organic substances (feeds, animal wastes, etc.) deposited in the Lake. In essence, the lake quality has manifested declining trend.

2. Coping mechanisms of Buhinons

The coping mechanisms of local leaders include conduct of trainings, legislation of ordinances, the organization of the Sinarapan Sanctuary Management and Development Council (SSMDC) which was envisioned to develop policies and implement programs, projects and activities that will ensure sustainable population of sinarapan, and federation of the youth sector for environmental management.

2.a SEARCA –SFRT Project Interventions

Interventions made through the SEARCA-SFRT project include TNA and IEC assessment, conduct of FGDs and SWOT analysis, conduct of trainings including the training on Technology of Participation (ToP), Sloping Land Management Technology, Basic Law Enforcement, and skills training which include Organic Fertilizer Production, Bio-intensive Gardening focused on Container Gardening for the Urban Barangays, Meat Processing, Fish Processing and Vinegar Production. Membership to the SSMDC of the CSSAC SFRT team resulted in the development of better action plans of the council. IEC materials developed include 2007 calendar, posters and bookmarkers all carrying advocacy messages for the sustainable management of Lake Buhi. A homepage was also developed posted at the Freewebs.com and a radio program in Buhi was carried out from March to May 2007 at the "Radyo Natin" in cooperation with the "Samahan ng mga kababaihan ng Sta. Clara" for the purpose of disseminating results, creating awareness and strongly advocating institutional collaboration for the sustainable development of Lake Buhi.

3. Inventory of Fish Cages and Other Lake Uses

On the inventory of fish cages, the actual count resulted to 15, 597 cages; 70% measures 10x10m and 30% measures 10x25m. Actual area occupied was estimated at 226.2 hectares. The current fish cage load exceeds carrying capacity by 33.7%.

Other lake uses include the generation of hydropower that produces 5.5 mkwh of clean energy from Lake Buhi, irrigation for 12,000 hectares of ricelands, navigation and tourism.

4. Analysis of Relevant Ordinances

There were five relevant ordinances passed related to fish cage operation, sanctuary management and watershed management and eight (8) enabling resolutions. These ordinances were found to be relevant and founded on generally accepted principles. However, the LGU officials had been weak in their implementation since monitoring and evaluation was not provided for, some ordinances / resolutions were not properly disseminated, and there was inefficient implementation due to "*compadre system*" and "*utang na loob*" syndrome.

5. Selection of Potential Sanctuary Sites for Sinarapan

On the selection of the potential sites for sinarapan sanctuary, Lakelets Manapao, Catugday and Pagiriran were compared. Lakelet Catugday has bio-physico-chemical properties comparable to Lakelet Manapao. Lakelet Pagiriran is not a potential site due to absence of phytoplanktons.

ToP training came up with an agroecosystem analysis and management prescriptions for the sustainable development of Lake Buhi.

B. Agro-ecosystems Analysis

B.1 Current Reality Assessment

The modified Agroecosystems Analysis for Sustainable Development (AASD) is an analytical methodology that requires the participation of stakeholders. The process of discovery, learning, decision and action are critical elements of the methodology of which the stakeholders should actively partake. The AASD provides a step-wise process of understanding and establishing critical decisions considering the multifarious factors in the environment where the given resource is located. The current reality assessment articulates the stakeholders' understanding of the current conditions of resources and provides insights and perceptions as to why they have the present scenario.

The following is a synthesis of the current reality assessment provided by the stakeholders as they have gone through a process of discovering and learning of patterns and trends in view of the present state of conditions in Lake Buhi and its peripheries. The presentation is clustered according to the three major eco-zones present in Lake Buhi and its peripheries:

1. Upland and Forest Ecosystem

a. People

- Lack of Political Will
  -Poor enforcement of laws

-Municipal Ordinances are not properly imposed and strictly implemented

- Lack of personal concern on the status of Lake Buhi resulting to poor water quality
- Poor awareness of the community on the effects of water pollution
- Dawn of capitalists
- Lack of Basic Services
- Resistance to change
- Unconcerned about lake development

b. Economy

- Potential for local/foreign tourism
- Low productivity
- Limited livelihood opportunities
- Existence of unlicensed fish cage operators and feed dealers
- Absence of diversified livelihood opportunities in the lowlands
- Lack of capital
- Increased production cost
- High fish cage density
- Low Government Revenue (Tax collection is low)

c. Environment

- Degradation of Lake Buhi and watershed is at its critical level
- The forest is now vanishing because of human settlement
- Low adoption of proper soil and water management technologies
- Land use conversions
- Soil degradation due to erosion
- Use of Chemicals in crop production
- Near extinction of Sinarapan
- Deteriorating quality of H_2O affecting local economy
- No concrete local programs for ecological sustainability
- No concrete project for the watershed

d. Cross Cutting Issues

- Recognition of Indigenous People's ancestral domain
- No land use plan
- Deteriorating peace and order condition
- Conflicting Laws

2. Lake and Rivers Ecosystem

a. People

- Majority depends on the Lake for sustenance

- Poor discipline of community especially on waste management
- Lack of education and technical knowledge
- Lack of information on agricultural development
- Poor management of resources

b. Economy

- Lake is no longer productive
- Only few persons are gaining economically
- There are many fishcages
- Sinarapan is Buhi's economic and tourism edge but now it's nearing extinction
- Buhi is known for its high quality tilapia
- With zoning ordinance but not properly implemented
- Fishing technology currently adopted is not sustainable
- Abundance of Water Hyacinth

c. Environment

- Poor status of Lake such as shallowing
- Significant reduction in lake area due to erosion and
- siltation
- Declining capacity of the Lake for natural production
- Poor water quality
- Sedimentation
- No regular water quality monitoring
- No sustainable agricultural development plan
- Slow efforts for an effective sinarapan sanctuary management
- Floating cottages in the Lake are contributory to poor quality of water

3. Lowland and Peri-urban System

a. People

- Hard headed
- Crab mentality
- Lack of concern for the Environment
- Lack of concern for others
- Poor sanitation
- Improper waste disposal
- Poor health and sanitation practices
- Rapid increase in population
- Low literacy among marginal fishermen
- Malnourished children and adults (poor health condition)
- No political will to implement Laws & Ordinances

b. Economy

- Low income especially for marginal fishermen

- Lack of livelihood opportunities
- Poor collection strategies for fisheries fees
- Poor collection of regulated fees for fish cage operators
- No updated inventory of fish cage operators
- No local revenue generated from Peoples' Energy Services, Inc
- Big Time Operators – Tax Evaders!
- Presence of dummy fishcage operators

c. Environment

- Lake is polluted, crowded and congested
- Lakeshore is congested with squatters
- Polluted and Overused Lake
- More lake reclamation
- Forest Denudation
- Fish cages along tourism area
- Dumping of garbage along lake shore
- Lake used as toilet

e. Other issues

- Overlapping of functions / power on the management of the lake
- No comprehensive plan for the conservation of Lake Buhi
- No participative planning
- More Planning - No Action
- No coordination among agencies/sectors/offices
- Lack of funding support for tourism/environment
- Lack of infrastructure support system

B.2 Systems Properties

Productivity

The Buhi agroecosystems is considered a multiple-use natural resource. Resource use patterns indicate that water is its primary product and is used by the communities for fisheries, power generation, irrigation, navigation and tourism. This shows that the systems' products and services is the major economic lifeline of Buhi's communities. Indications show however, that the ability of Buhi agroecosystems to increase or even sustain productivity levels is in threat. The systems' ability to provide adequate volume and quality water seems to be constrained by many factors such as forest denudation and its attendant effects such as erosion and siltation, poor lake management resulting to unregulated number of fish cages, infiltration of domestic sewerage leading to a eutrophic situation. These factors lead to a situation where the productive capacity of the system declines. This becomes more critical as we view the system in a multi-purpose character. Notwithstanding, the clear limits of resource capacity of the

resource system and the current resource use patterns tend to be depleting rather than moving towards resource conservation. In fact, the near extinction level of "sinarapan" is a warning signal that the current trends are now putting the resource and the dependent community at its highest risk.

It seems that development efforts in the past were not fully grounded. There was rather a rush at utilization than at resource conservation. Temporal patterns indicate that resource productivity was viewed at introducing species or infrastructures than at enhancing the natural productive capacities of the resource. Even the hydraulic control structure constructed in the 1980's which was claimed to be designed to regulate and manage water use is now considered to be an "environmental impediment" to the "natural flushing" of the Lake.

Stability

The resource capacity levels of Lake Buhi and its peripheral resources are parameters to which clear decisions on resource use must be based. Present indications on resource use show that the agroecosystems' natural productive capacity and its environmental integrity is of a declining trend as manifested by (1) loss of the "sinarapan", (2) unstable water supply and poor water quality (class C), and (3) heavy dependence of cultured fish on external source of feeds. These are consequences of several negative factors which affected the stability of the system like (1) forest encroachment, (2) siltation, sedimentation and water pollution, (3) endemic species displacement, and (4) poor management and regulation. Such factors have caused stresses to the natural functioning of the resource, thus, making the productive capacity of the agroecosystems unstable over time. This variation in the Lake's productive capacity tended to establish a declining trend line suggesting that the natural resource is now unable to adequately recover from the stresses. The use of increased amounts of feed and feed supplements to tilapia in fish cages and the longer time required for the fish to reach marketable size are clear indications of the very low natural and internal feed sources in the Lake to sustain the current tilapia population. Unfortunately, this coping mechanism has negative effects on water quality.

Sustainability

Natural resource systems have a distinct capacity to restore itself and cope with disturbances and stresses to the system. Usually, this is manifested as the trend of productivity levels goes to normal or even higher levels after periods of stresses. Sustainability as an agroecosystems property is viewed in such context. In the Buhi agroecosystems, particularly in the Lake eco-zone, declining productivity trend and especially the near loss of "sinarapan" are indicators of a system experiencing difficulties in coping

with stresses. Factors such as overcrowding of fish cages, excessive artificial feeding, and sedimentation negatively affect system's behavior. The eutrophic level of the Lake may indicate to some extent that the Lake has significantly diminished its natural capacity to sustain aquatic life under normal and natural conditions. These factors unless regulated or totally eliminated would prove to be environmental impediments to the natural capacities of the Lake to sustain livelihood.

Equitability

Policy provides a far ranging impact to resource use and to the overall integrity of a natural resource. In most part, the impact of a bio-technical solution revolves largely on a policy solution. As such, equitability of a resource system's use can be a function of how policy decisions are carried out to ensure productivity on a long term basis. It may also refer to the wide spread of participation of stakeholders in the decision making processes and in the sharing of benefits. In the Buhi agroecosystems, policies played a significant role in the current situation of the resource. In fact, there was no lack of laws and policies. This was even matched with an adequate number of mandated agencies to do development. On the other hand, this provided a scenario of confusion and conflict. Each agency and stakeholder pursued its own mandates and interests resulting to a management overlap that further resulted to a bureaucratic failure. The basic question of who should rightfully be in control or have management jurisdiction over the Lake and its resources is still unanswered. Essentially, these issues of equitability hinder the move to a technical solution to the present environmental problems of Lake Buhi.

It is dismaying to note that the same questions and issues were posed 20 years ago, which until now remain unresolved.

B.3. Development Issues and Challenges

1. **<u>Management and control of Lake Buhi and its resources: Who is in charge?</u>**

This has been a long running issue in which stakeholders should confront and finally settle. Some sectors complain that the management overlap and bureaucratic failure created by the conflicting laws and interests of the key players have hastened the environmental deterioration of Lake Buhi. Others argue that the Local Government Unit of Buhi who should be rightfully in control of local resources was not strong enough to assert its power and role amidst many interests and players.

It should be noted that key decisions about water use or lake use were made without the participation of the local government unit. As gathered from key informants, it should also be on the record that agencies provided by law to have jurisdiction over the resource and those agencies

who benefited from the lake's resources have not fully taken responsibility over the management of the Lake nor have adequately provided local investments as payments for the resource environmental services.

The question now still remains: Who should be in control and take a unifying effort to manage and conserve Lake Buhi and its resources?

2. Resource Use Conflicts or compatibilities: Water for irrigation? Water for power? Water for fisheries? Water for navigation? Water for tourism?

Lake Buhi and its peripheries is a multi-use resource. Water as its major product is used for (a) energy generation, (b) irrigation, (c) fish production, (d) water transportation, and (e) recreation and tourism. Current resource use patterns show the heavy dependence of these uses on water. As such, a wide variety of users depend for livelihood or services on the lake system and its major product. The variation of water levels or the amount of water on lake surface area used by a specific user significantly affects the productivity of other resource users.

In fact, the hydraulic control structure was constructed in the 80's to serve the purpose of managing and regulating water use. Most of the stakeholders, however argue that the structure may have hastened sedimentation resulting to poor water quality.

The question is: How should we strike a balance in water use to equitably serve the needs of other users and establish the best combination of uses that considers both economic and ecological considerations?

3. Fish cages: Where have all the municipal fishermen gone?

Research studies on lakes have indicated that a lake has limits on the fish stock density it can sustain. It was estimated that only about 10% of a lake's surface area can be optimally used to sustain fish cages. An increase above the 10% surface area for fish cages may result to the following: (1) increase external inputs on feeds due to lack of natural food, (2) increase in OM levels and sediments due to excessive feeds, (3) poor water quality, (4) significant displacement of endemic fish species, and (5) alteration or displacement of navigational lanes.

Current estimates show that fish cages had a net covered surface area of about 70 to 80% of the total Lake's surface area, impounding an estimated 2,837.5 tons of feeds per cycle on the Lake. Such stocking pressure has created significant changes in the lake's natural functions. The "kanuba" or the sulfur upwelling which was blamed for the massive fish kill in 1998 was ruled out as the cause of such phenomenon. The fish kill was attributed to organic matter upwelling brought about by high amount of decaying feeds and other nutrients loaded on the Lake (Report on 1998 fish kill).

Findings also showed that fish cage operation is a big business controlled by a few big time operators. Key informants revealed that local fisherfolks act as dummies of these big time operators who are not even residents of Buhi. In addition, per Municipal Ordinance No. 004 s 1989, a license fee to operate of only P50.00 is required annually and an annual water rental fee of 20 centavos per m^2 of fish cage must be paid to operate a fish cage business. With the very minimal fee required to run a fish cage business, how can Buhi prevent the proliferation of fish cages? What is in store for the marginal fisherfolks?

4. Sinarapan: Have they left home?

Sinarapan has placed Buhi in the world map. In fact, the LGU has produced a brochure intended to promote eco-tourism in Buhi, which highlights Lake Buhi as the Home of World's Smallest Commercial Edible Fish. But where is the "Sinarapan"? Have they left home? Or were they driven away from home?

The introduction of exotic species over the years had been blamed for the near extinction of "Sinarapan". Temporal patterns show that as early as the 60's, carp, gurami, shrimps and tilapia had been introduced to the Lake, displacing the Sinarapan population. This was further aggravated with the introduction of sakag, a fine mesh push net used in the capture of sinarapan in the 70's and with the tilapia fish cage technology in early 80's which altered the natural habitat due to the use of artificial feeds.

Now, "sinarapan" (*Mistichthys luzonenzis),* is listed in the IUCN's red list of threatened species.

5. Ecotourism: Is it really a local potential?

Why would a tourist go to Buhi? There are only two reasons: Sinarapan and Lake Buhi. Without them, Buhi is just an ordinary town. With the present condition of Lake Buhi and the vanishing Sinarapan, what is there left as a local eco-tourism potential?

6. Aetas: Where are they in the development framework?

The Buhi Watershed is identified as an ancestral domain of the aetas. The National Commission for Indigenous Peoples (NCIP) has initiated efforts toward the issuance of a Certificate of Ancestral Domain Title (CADT) to the indigenous peoples. Several sectors, however have opposed such moves. They argued that the NCIP's efforts are too encompassing as to encroach into the rights of the other sectors. They may be right but these suggest that the recognition of the rights of the indigenous peoples in the area is not widely acknowledged. Even in documents of development plans for the area, watershed or municipal level, the plight of indigenous peoples is not adequately addressed.

CONCLUSIONS

Based on the objectives and the findings of this study, the following conclusions are derived:

1. The agro-ecological practices in the upland and buffer zones of Lake Buhi by the upland farmers and IPs, and the inland fishing practices of the fisherfolks, across gender are not favorable for the sustainable development of Lake Buhi. The perceived effects and the results of actual analysis of the bio-physico- chemical properties of the water, sediments and phytoplanktons are indicative of lake eutrophication.

2. The LGU and other sectors have implemented some coping mechanisms for the sustainable development of Lake Buhi, but efforts are not concerted. Each major stakeholder - the LGU, the National Power Corporation / Buhi – Barit Watershed Area Team (NPC-BBWAT), the National Irrigation Administration (NIA), the National Commission for the Indigenous Peoples (NCIP), and the local stakeholders carry out individual programs and projects in the watershed and in the Lake based on their respective mandates. Such multi-system of governance of a common resource led to confusions among the stakeholders and local constituents that resulted to ineffective lake system management. The organization of the Sinarapan Sanctuary Management and Development Council (SSMDC) was envisioned to develop policies and implement programs, projects and activities for the sustainable population of Sinarapan but the council still has to prove its worth to get funding support and to have its policies implemented by concerned organizations / parties. The coping mechanisms made through the SEARCA SFRT project, particularly the training on Technology of Participation for the analysis of Buhi agroecosystems and the other trainings and IEC activities hope to initiate a concerted effort among the major stakeholders and even the youth for the sustainable development of Lake Buhi.

3. The current inventory of fishcages of 15,597 occupying an actual area of around 226 hectares is 33.7% in excess of the Lake's carrying capacity. The other uses which include generation of hydropower, irrigation, navigation and tourism are in conflict with one another. Fishcages occupy navigational lanes which prove to be hazardous to the Lake transport sector; the need of water for hydropower and irrigation can pose a threat to fishcage operation; and massive fishcage operation that resulted to fouling odor of the Lake is a drawback to the tourism industry.

4. Municipal ordinances and resolutions passed are in support to the sustainable management of the Buhi watershed, the Lake, and the Sinarapan sanctuary. Its effective implementation can warrant

sustainable development and management of the rich resources of Buhi.

5. Lakelet Catugday has bio-physico-chemical properties similar to Lakelet Manapao which have favored the growth of Sinarapan population. The absence of phytoplankton in Pagiriran disqualifies it as potential Sinarapan Sanctuary.

6. The ToP was an effective facilitation tool for making an agroecosystems analysis. The management prescriptions generated can be the basis of future development interventions for the sustainable development of Lake Buhi.

RECOMMENDATIONS

From the results and conclusions generated in this study, the following recommendations are made:

1. More favorable agro-ecological farming practices in the uplands and alongside the Lake should be introduced to the farmers to lessen their impact on the Lake, particularly from soil erosion, siltation, chemical contamination and organic matter loading. Kaingin and slash and burn, which are the common practice of the upland farmers and IPs in the hilly and sloping areas of Mt. Asog and Mt. Malinao should be replaced by Sloping Land Management Technologies, and the Sloping Agricultural Land Technology is one of them. Sustainable agricultural practices for clean agriculture should also be introduced to the farmers. Growing of swine, particularly in commercial quantities alongside the Lake should be prohibited by the LGU. Draining of septic and other domestic wastes into the Lake must also be checked by proper authorities. Strict implementation of the Inland Fishery Act, that provided for the use of only 10% of the inland waters for fish production should be strictly implemented and observed through the strict implementation of the ordinance on registration of fish cages and regular counting and monitoring of fish cages in the Lake by proper authorities - the LGU Police Force with the personnel of the Lake Development Office. The practice of some investors of using dummy operators in Buhi should be corrected by imposing fines and /or take-over of fish cages by the LGU for those found guilty of such violation, which are also stipulated in Municipal Ordinance No. 2, series of 1992. Fishing technologies used by the fish cage operators should also be monitored to minimize nutrient loading from the use of commercial feeds, otherwise, alternative technologies in fish production must be introduced.

2. Initiatives and development efforts for the sustainable management of the rich resources of Buhi, particularly the Lake and its surrounding watershed should be made concerted. Relevant sectors in Buhi should

be organized to bring to the attention of the legislators of our government the need of gathering in an assembly all major stakeholders representing the National Government Agencies in the country – the NPC, NIA, NCIP, the Department of Interior and Local Government (DILG) with the LGU of Buhi to be able to harmonize the laws that empowered them to have a stake on said resources and come up with complementation strategies that can ensure sustainable use of the Lake and the watershed. A memorandum of understanding should be signed among them to ensure enforcement of said agreements. External and internal monitoring teams must also be organized to keep track of the developments that will happen in the use of said resources.

3. The prescribed area for use in fish cage operation should be strictly observed to ascertain that production system in the Lake will not exceed carrying capacity. Multiple uses of the Lake should also be studied for better complementation and to ensure sustainability of lake use. The Solid Waste Management Act and the Municipal Ordinance No.3 series of 2003 should be strictly enforced to ensure the cleanliness of the surroundings in Buhi, including the Lake to improve the tourism potential of the municipality.

4. All municipal ordinances and resolutions passed relevant to natural resource management and environmental protection were meritorious and founded on some constitutional provisions for common good. It is therefore recommended that stricter implementation of the local ordinances should be carried out by the LGU. The LGU officials are also advised to inhibit themselves from engaging in forbidden entrepreneurial activities, transactions or contract, i.e. those that would involve their official interventions and set themselves to their constituents as models of impartiality, integrity and transparency in public governance. They must enforce the rule of law in all forms of legislation, administration and execution without fear and self preservation. These ethical standards of governance will earn high moral ascendancy to the whole constituents.

5. A comprehensive assessment of Manapao and Catugday lakelets as specialized ecological niche of endemic sinarapan has not yet been conducted, thus the findings of the study on the bio-physico-chemical properties of the lakelets can be considered as initial ecological requirements for determining other possible sites for the sustainability of sinarapan population. The basic requirement considered in choosing potential sanctuary is the availability of water in the lakelet year round. Since other lakelets dry up during summer, lakelet Pagiriran was considered as potential site. However, the absence of phytoplanktons in the lakelet indicates that there may not be enough natural food in the lakelet to support sinarapan and other fish species. It is therefore recommended that the SSMDC should take seriously its role in ensuring

sustainable population of Sinarapan in Lakelets Manapao and Catugday. Also, since sinarapan has been introduced to Lakelet Makuwaw, the watershed around this lakelet, including Manapao and Catugday should be protected from continued denudation to ensure availability of water for the sustainable population of the smallest commercial fish. The Council must also take active role in the implementation of Municipal Ordinance No. 053 series of 2005 to prevent the illegal owning and use of chainsaws to prevent further denudation of the watershed. Also, since Sinarapan are still being sold not only in Buhi market but in other markets in Bicol, continues monitoring should be made by the SSMDC to ensure that no illegal capture of sinarapan would be done in the sanctuaries. The proposed amendments to Municipal Ordinance 019, series of 1997, which declared Manapao and Catugday as sanctuaries, particularly the provision of budget to be taken from the EDF, to place the sanctuary management under the agriculture and fisheries program of the LGU, and the deputization of the Bantay Lawa to be selected from among the members of the SSMDC residing near the lakelets should be followed through to ensure provision of budget in support to the activities of the SSMDC.

6. It is also recommended that any further planning for the sustainable use of Buhi's natural resources – the Lake and its watershed, should be anchored on the management prescriptions that were generated through participatory analysis made by the stakeholders during the ToP training in Buhi.

REFERENCES

American Public Health Association. 1996. Standard Methods for the Examination of Water and Waste Water: 12th Edition. New York.

ARCBC. 2006. Profiles of Major Lakes in the Philippines.

Associate in Rural Development. Undated. Technology of Participation. Basic Group Facilitation Methods. Manual for Course Participants. Center for Local Governance. Graduate School. Ateneo de Naga University. pp. 3-52.

Belza, D. N., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines. Sept. 21-22, 2006.

BFAR and UNEP. 1996. Action Plan for the Sustainable Freshwater Ecosystem Management of Buhi Watershed.

Bustarga, H.C 2004. Growth Performance of Water Hyacinth (Eichhornia crassipes) in Lake Buhi. CSSAC. (undergraduate thesis)

Camposano, S. 1997. An pagtanom sa bakilid na daga. CSSAC Ext. Div. Techno-Series.

CLUP of Buhi. 2002. Socio-economic profile of Buhi. pp. 68.

Collao, E., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.

Conway, G.R., and Sajise, P. 1986. The Agroecosystems of Buhi: Problems and Opportunities. Proceedings of a workshop held in Naga City, Bicol. Nov. 14-18, 1985. pp. 49-75

Conway, G and Sajise, P. 1986. Agroecosystems Analysis of the Buhi Watershed: Problems and Opportunities. Bicol River Basin Development Program.

Declaro, R., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.

Enger, E.D & Smith, B.F. 1983. Environmental Science. A Study of Interrelationships. 5th Ed. WMWC Brown Publishers. Boston
Espiritu, S., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.
Favoreal, P., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.
Fernandez, R. Jan. 19, 2006. Why fishkill occur in lakes. Manila Bulletin
Gindelberger, B. 1981. Fishery Management in Camarines Sur, Philippines: Why "Sinarapan" almost disappeared from Lake Buhi, ICLARM Newsletter 4 (3):3-5.
Gonzaga, A. O. III. 2002. Effects of Nitrate and Phosphate Concentration in Algal Biomass in Lake Buhi. CSSAC (Undergraduate Thesis).
Guzman, Ruth S. & R. Z. Guzman. 2000. Environmental Education for Sustainable Development, Wisdom Advocates Publishing. 29 Pat. Senador St., San Francisco Del Monte, Quezon City, Philippines.
Huertas, F. Undated. Origin of Buhi. Unpublished document. pp. 9.
Infante, N., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.
ILEC-UNEP. 1997. Major Lakes of the World, Lake Buhi
Lai, Chun K., Ma. Dolores N. Yabut, Jesus C. Fernandez & Wilfredo H. Libunao. 1999. Participatory Methods for Upland Systems Research and Development: Highlights from a Training Course in the Philippines. ICRAF. Philippines, 2/F Coll. of Forestry and Natural Resources, UPLB, College, Laguna.
Lavadia, E., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.
Lavadia, Eleno Sr. 2000. Lake Buhi Observation/Historical Profile. pp. 1.
Laws, E.A., 1993. Aquatic Pollution: An Introductory Text, 2nd Edition, John Wiley and Sons Inc.
LGU Buhi. 2004. Municipal Socio-Economic Profile of Buhi, Camarines Sur
Llesol, C.B. 2006. Basic Law Enforcement and Criminal Procedures. Unpublished Lecture Materials. pp. 26.
Llesol, C. B. 1994. Evaluation of Soil and Water Conservation in Luzon, MRM Special Problem, CSSAC, Pili, Camarines Sur.
Miller, T.G. 1994. Environment: Problems and Solutions. Wadsworth Publishing Co. Belmont Ca.
Mora, I. A. Municipal Basemap, Buhi, Cam. Sur.
Mora, I. A. General Land Use Map. Mun. of Buhi, Cam. Sur.
Mora, I. A. Map of Rinconada (Cam. Sur), 4th Congrssional Dist.
Mora, I. A. Map of Camarines Sur.
Mora, I. A. Map of lake Buhi, home of the smallest commercial fish in the world; "Sinarapan".
Mora, I. A. Map of Lake Buhi.
Nazarrea, A., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.
Nazarrea, M. 2005. Saving Lake Buhi, Saving Lives: Management Research Report. Asian Institute of Management.
NEDA R-5. 2001. Proposed Development Plan of the Bicol River Basin Watershed Management Program.
Noble, A.H., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.
NSO. 2000. Total population, household population, and number of households, by province, city, municipality and Barangay as of May 1, 2000. pp. 2.
Olaño, A., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.
Ordinance No. 1, S. 1976. An ordinance regulating fishing /or fisheries in the Municipality of Buhi and for other purposes. pp. 7.
Ordinance No. 4, S. 1977. An ordinance banning the catching of Sinarapan at night with the use of light, motorized or non-motorized banca and for other purposes. pp. 2.

Ordinance No. 5, S. 1977. An ordinance regulating the size of hole of fishnet and the violations and penalties of the provision thereof. pp. 2.
Ordinance No. 2, S. 1982. An ordinance amending Sections 3,9,12(e) and 13 of the Fish Cage Ordinance in 1982. pp. 2.
Ordinance No. 97-019. An ordinance declaring Lakelets Manapao and Catugday in Barangay San Ramon, Buhi, Cam. Sur as Sinarapan Sanctuaries and provisions for their conservation and management. Enacted 19 Nov. 1998. pp. 5.
Ordinance No. 03-040. The Comprehensive Solid Waste Management Ordiance. Enacted 31 July 2003. pp. 11.
Ordinance No. 05-053. An ordiance regulating the possession, ownership, sale and use of chainsaws in the Municipality of Buhi, Cam. Sur, prescribing penalties for its violation and for other purposes. Enacted 25 August 2005. pp. 5.
Oliva, E. 2005. Master list of barangay officials and NGOs, POs in Buhi, Cam. Sur. LGOO V DILG. pp. 7.
PCARRD – PAW B. 1993. Conservation of Biological Biodiversity in the Philippines. PCARRD Book Series No. 132, 1997. Los Baños, Laguna.
Proceedings of Training on sustainable freshwater ecosystem management. 1996.
Rempillo and Bon, 1996. Action Plan for the Sustainable Freshwater Ecosystem Management of Buhi Watershed. BFAR and UNEP.
Resolution No. 04-016. Resolution favorably endorsing to the DENR, Iriga City, Res. No. 001 S. 2004 of the SB of Buhi entitled "Resolution strongly expressing opposition and urgently requesting all concerned authorities to stop the quarrying at Barangay Burocbusoc, Buhi, Cam. Sur". Adopted 19 Feb 2004. pp. 2.
Resolution No. 04-090. Resolution enjoining all Barangay Councils in the municipality to conduct massive cleaning and greening activities to protect and enhance the environment. Adopted 15 July 2004. pp. 2.
Resolution No. 04-108. Resolution declaring every Saturday of the week as general clean-up day in the municipality. Adopted 4 Aug. 2004. pp. 3.
Resolution No. 04-131. Resolution enjoining NGOs, POs, civic organizations, religious and other sectors to consider as part of their community project involvement, the "Adopt an area/park program", in support of the municipality's cleanliness, greening and beautification program. Adopted 9 Sept. 2004. pp. 2.
Resolution No. 04-161. Resolution opposing HB No. 1224 otherwise known as "The Lake Buhi Sanctuary Act of 2002". Adopted 25 Oct. 2004. pp. 2.
Resolution No. 04-163. Resolution authorizing the Mun. Mayor, Hon. Diones N. Belza, to designate an Executive Officer to facilitate the organization and planning of the Environment Management Services program and activities. Adopted 04 Nov. 2004. pp. 2.
Resurrecion, N and Gonzales, M. 2006. Profiles of Lake Buhi. Haring Ibon. Haribon Foundation for the Conservation of Nature. Manila, Philippines
Roxas, N., Godilano, et.al. 2005. Socio-economic and Physical Profile of Buhi.
Salvamante, E., 2006. Training on Technology of Participation. Buhi, Cam. Sur, Philippines.
Santelices, M.S. et al. 2001. Physico-Chemical Analysis of Lake Buhi. CSSAC. (Undergraduate Thesis).
SEAFDEC Aquaculture Department. March-April 1995. Aqua Farm News, Vol. XIII No. 2. Iloilo, Philippines.
Sergio, E. Undated. Sinarapan. The Worlds Smallest Edible Fish. Reprinted from 1974 issue of the Asia Magazine. pp. 2.
Soliman, V.S. 1989. Population dynamics of *Sinarapan (Mistichthys luzonensis Smith)* in Lake Manapao, Buhi, Camarines Sur, Philippines. Central Luzon State University, Muñoz, Nueva Ecija, Philippines (Unpublished M. Sc. Thesis).
Soliman, V.S. 1991. Exploitation rate, yield-per-recruit and virtual population of *Sinarapan (Mistichthys luzonensis)* in Lake Manapao, Buhi, Camarines Sur. Paper presented at the 13th Annual Scientific Meeting of the National

Academy of Science and Technology, Philippine International Convention Center, Manila, 9-11, July 1991.
Soliman, V.S. 1994. Conservation and Management of Lake Manapao (Philippines), a "*Sinarapan*" (*Mistichthys luzonensis)* sanctuary: Status, problems and solutions. Mitt. Internat. Verein. Limol. 24:279-283.
Soliman, V.S. S.C. de Jesus and M.F.A. Sergio. 1998a. Managing *Sinarapan* (*Mistichthys luzonensis)* in Lake Manapao, Buhi, Camarines Sur: Insights from its Biology and Population Dynamics. Paper presented at the National Seminar Workshop on the Conservation and Ecological Management of Philippine Lakes in Relation to Fisheries and Aquaculture. L.B. Soriano Hall, Innotech Complex, Commonwealth Avenue, Diliman, Quezon City, 23-27 August 1997. Sponsored by PCAMRD, Los Baños, Laguna; BFAR, Quezon City; and SEAFDEC Binangonan Research Station, Binangonan, Rizal.
Soliman, V.S., N.W. Dullesco and M.F.A. Sergio. 1998b. *Sinarapan* Conservation Project: Strategies for Conserving and Managing Sinarapan (*Mistichthys luzonensis Smith),* the "World's Smallest Commercial Fish". Paper presented during the 2nd Southern Luzon Interzonal R&D Review. Arisabel Clubhouse, Los Baños, Laguna. 18-20 November 1998. Sponsored by PCAMRD, Los Baños, Laguna and University of the Philippines in Los Baños, Laguna.
Soliman, V.S. and M.F.H. A. Sergio. (in press). Population dynamics of *Sinarapan* (*Mistichthys luzonensis)* in Lake Manapao: a Decade of Stability.
Soliman, V.S. and M.F.H. A. Sergio. (1997). Review on the biology and population dynamics of *Sinarapan* (*Mistichthys luzonensis)* (Unpublished manuscript), 20 pp
Soliman, V.S. and Antonio B. Mendoza, Jr. International Institute of Rural Reconstruction (IIRR May 2003). Reviving the stock of sinarapan, the "world's smallest commercial fish": Adapting biodiversity conservation and co-community science application. Integrated Watershed Management Approaches to Alleviating Poverty in the Bicol Region, Philippines Learning from the Past Experience
SSMDC, 6 Jan 2006. Minutes of the Sinarapan Sanctuary Mgt and Dev't Council. pp. 3.
SSMDC, 2 Feb 2006. Minutes of the Sinarapan Sanctuary Mgt and Dev't Council. pp. 4.
SSMDC, 30 Aug 2006. Minutes of the Sinarapan Sanctuary Mgt and Dev't. Council. pp. 3.
Technical Investigation Team. 1998. Report on the Investigation of Massive Fish Kill in Lake Buhi, Buhi, Cam. Sur. DA/RFU5/BFAR-CO/LGU – OPA. pp. 4.
Technical Investigation Team. 1999. Report of On-Site inspection. Water quality survey and interview related to the fish kills in July 23-24, 1999. DA/RFU5/ BFAR-CO/LGU – OPA. pp. 3.
Wetzel, R.G 1983. Limnology. Sounders College Publishing.
Wider. 1991. The Environmental and Emerging Development Issue. World Institute for Development Economies Research of the United Nations University.
http://www.nrc.govt.nz/reports)
http://www.mgs.md.gov/coastal
http://www.deq.state.mi.us/documents/deq-land-sesc

Development of In-service e-Learning Environmental Education Content for Elementary, Middle and High School Teachers in the Republic of Korea

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INTRODUCTION

Background and Research Objectives

The human race has enjoyed material abundance due to the development of science, technology and the economy. But such growth has come at the expense of the environment. The ecosystem's cycle and resilience have both begun to deteriorate. Indeed, the human race is now facing an ecological crisis. This is a man-made crisis: human beings have not cherished and loved but exploited and damaged nature, the basis of all life. It is fair to say that the contemporary ecological crisis began when the link between all creatures and the natural environment began to break, which in turn led to the collapse of the dynamic interaction which sustained the earth itself.

The ecological problems arise from scientific and technological developments, urbanization, industrialization, population increase and economic growth. But the fundamental reason lies in a wrong perception of the environment. To solve the ecological problems, not only environmental education, but also various other approaches are required, including those of an environmental engineering, legal and administrative nature. As ecological problems are so complex, they can be resolved only through multi-disciplinary and inter-disciplinary approaches. Most important of all is environmental education, which helps tackle environmental issues in preventive, fundamental ways in the long term.

In this regard, the quality of teachers currently in charge of such education is critical to its systematic implementation. Helping teachers become environmentally knowledgeable and skilled requires pre-service education for future teachers at teacher training centers and in-service education for current teachers. In particular, environmental training is essential to meet the changing demands of both time and society as well

as to accommodate academic changes in environmental education. However, there is a lack of education courses for teachers and environmental training programs. With inadequate access to both time and space, even the existing programs do not produce the designed outcomes.

Cyber training can be a good solution to the problems with teacher education. It improves access to education opportunities as it overcomes the limitations of time and space and provides hands-on experience through multimedia materials that reflect the real world. Against this backdrop, this study is aimed at developing In-service e-Learning Environmental Education Content (IeEEC) for elementary, middle and high school teachers, which can be provided at cyber training centers.

Research Content and Methods

The research contents to develop IeEEC for elementary, middle and high school teachers include: i) presenting models for developing IeEEC, ii) planning IeEEC, iii) designing and developing IeEEC, and evaluating IeEEC.

To develop IeEEC for elementary, middle and high school teachers, this study employs research methods including a literature review, content analysis and expert consultation. To evaluate IeEEC, evaluation criteria was developed as can be seen in Table 1. The research group commissioned evaluation to eight experts in environmental education of each school level. Each expert rated each question from 1 (not relevant at all) to 5 (highly relevant).

Table 1. Evaluation criteria of IeEEC

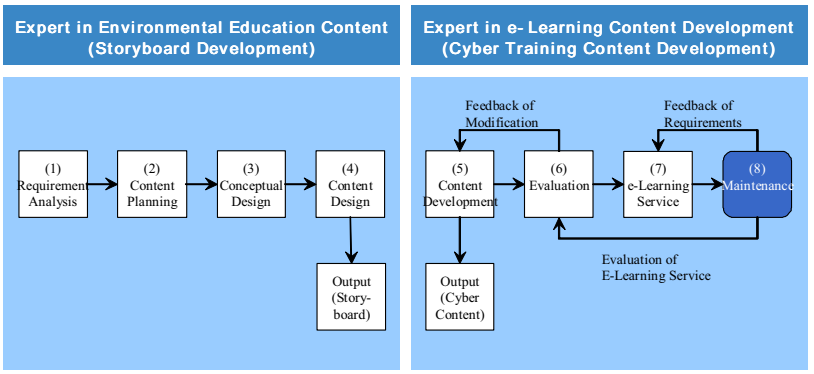
Category	criteria
Overall Content	Relevance of Content
	Systemacity of content
	Difficulty of content
	Difficulty of terms
	Fun of content
	Allotment of hours
Development and structures of content	Introduction to learning
	Content for learning
	Summary and Evaluation
	Further studies

Models for developing In-service e-Learning Content for Environmental Education

Models for e-Learning Content Development

To develop leEEC for elementary, middle and high school teachers, this study designed models for developing content as shown in Figure 1. The models have eight stages: requirement analysis, content planning, conceptual design, content design, content development, evaluation, e-Learning service and maintenance. The summary of each step is as follows:

Figure 1. Models of developing In-service e-Learning Content for Environmental Education



Source : Seo U-seok, Jeong Cheol-youg, and Lee Jae-ho (2006). Development of e-learning environmental education contents for elementary school teachers. The Department of Agricultural Education, Human Resources Development, 38 (3). p. 208

First, diverse requirements are collected mainly from users of leEEC for elementary, middle, and high school teachers and they are applied to content development.

Second, in the stage of content planning, overall Objectives for the content of each section are established before the number of hours for the general content and education sections are decided.

Third, titles for each section, as well as the titles and content of each education hour, are made before education hours are allotted, according to the more detailed content that has already been produced at the content planning stage.

Fourth, the detailed educational content of each educational hour is laid out in the form of a storyboard, on the basis of e-learning content teaching-learning models that the research group has developed.

Fifth, in the stage of content development, the leEEC storyboard, an output from the design stage, is developed into e-learning content. The

Sharable Content Object Reference Model (SCORM) is applied in content development.

Sixth, in the evaluation stage, the validity of IeEEC, which is an output from the content development stage, is commissioned to and confirmed by expert groups of each section.

Seventh, IeEEC service is provided for learners, after modification requirements from the evaluation stage are met.

Eighth, various requirements, which might arise during the e-learning service, are reflected upon and the quality of the service is maintained by continuously upgrading content.

Teaching-Learning Models of e-Learning Contents

To develop IeEEC for elementary, middle and high school teachers, this study has developed teaching-learning models. The models have four stages: i) Introduction, ii) Learning, iii) Summary and Evaluation, iv) Further Studies. The features of each stage are as follows:

Table 2. The Structure of the IeEEC teaching-learning model

Contents		Implementation Method
Introduction	▪ Introductory step ▪ Consists of simple flash animation to attract the interest of learners ▪ Suggesting the objectives and content for learning	Flash animation, narration
Learning	▪ Actual learning activity step(cognitive, psychomotor domain) ▪ Designed so that learners are encouraged to actually carry ▪ Considers off-line activities	Uses various methods, such as pictures, photographs, texts, clicking, photographing, dragging, arranging, recording, experimental and lab flash animation, and off-line activities
Summary and Evaluation	▪ Recapping step: Comprehensively organizes all learning contents ▪ Evaluation step: Uses various methods such as texts and narrations	Text(in bullet points) narration, flash animation text
Further Studies	▪ In-depth learning step ▪ Presents additional details related to a single unit of learning content or contents that should be learned in-depth through text and narration	Text, narration

First, "Introduction" is an introductory stage, which helps learners develop interests through simple illustrations, writings, photos and flash animations, and suggests the objectives and content for learning.

Second, "Learning" is an actual learning stage where illustrations, pictures, texts, games and animations are provided in various ways so that educators can not only provide environment-related knowledge and skills but also inspire [environment-related] action. Also learners can have experiences both online and offline.

Third, "Summary and Evaluation" includes the overall summary and evaluation of learning. Various methods such as texts, narrations, and games can be employed. In particular, virtual competitions with computers are staged in order to increase interest among teachers.

Fourth, "Further Studies" is a further learning stage, which provides materials and information for additional learning: related literature, websites, critical thinking, off-line activities, on-the-spot studies and surveys, etc.

Planning of e-Learning Content

Objectives of Content

IeEEC for elementary, middle and high school teachers should help teachers not only learn professional skills and knowledge related to environmental education but also help them acquire basic knowledge, improve their views of the environment, develop interests in environmental issues and put the [acquired] knowledge into practice. The ultimate objective of the IeEEC is to enable school teachers to more effectively and actively educate students at school by acquiring knowledge for environmental education. Therefore, the overall objective is to enhance professionalism in environmental education.

Subsequent targets to enhance the professionalism of school teachers in environmental education include: i) helping teachers see and recognize the relationship between human beings and the environment, ii) helping teachers have interests in the environment, iii) helping teachers acquire and understand detailed information related to the present and future interactions between human beings and the environment, iv) based on the information given, help teachers understand responsible ways to reduce or eliminate negative consequences of the relationship between human beings and the environment so that individuals and organizations can change their attitudes and take action. Factors that arise from this can be divided into awareness, interests, understanding and actions: all these factors represent the basic knowledge for each section.

Sections of Content and Purpose of Each Section

To develop IeEEC in line with the objectives and targets, this study uses three sections: i) Basics of Environmental Education, ii) Understanding of the Environment, and iii) Strategies for Environmental Education at School. Details of each section are as follows:

First, the section of "Basics of Environmental Education" includes basic knowledge and theories that are required of school teachers in giving environment education. In this section, teachers will fully understand the seriousness of environmental problems and the necessity of environmental education. Also teachers will study the history of environmental education

and grasp the objectives, targets, content, teaching-learning methods and evaluation of environmental education at school.

Second, the section of "Understanding of the Environment" helps teachers explore various themes in relation to the components of the environment. Representative themes include water, air, soil, animals and plants, and natural resources and energy. Each section will have social issues as themes or ones that need understanding. In this way, instructors of environmental education at school can have a better understanding of various themes. Also themes that environmental education instructors need to understand will be developed. Such themes should include more fundamental and commonly necessary subjects like the history, ethics, psychology, and policies of the environment, rather than social issues.

Third, the section of "Strategies for Environmental Education at School" provides practical aid for teachers on how to guide and educate students at school. According to the conditions of the particular school, environmental education can be divided into diverse categories like school activities, discretionary activities and special activities. Each category should have strategies for curricula, education and evaluation.

Content and Education Hours

Based on the objectives and targets set out above, IeEEC for elementary, middle and high school teachers was formulated. This is shown in Tables 3, 4, and 5.

Part 1 - Basics of Environmental Education has five categories:

1. Introduction to Environmental Education which deals with characters and problems of environmental problems and the relationship between environmental problems and education,

2. The History of Environmental Education which covers the history of domestic and international environmental education,

3. The Goals and Content of Environmental Education which includes the objectives, targets and content of environmental education,

4. The Teaching-learning Methods of Environmental Education which includes major teaching-learning methods of environmental education, and

5. Evaluation of Environmental Education" which deals with major evaluation methods.

There are ten education hours in Part 1. Although overall systems of elementary, middle and high schools are basically the same, distinct

Table 3. Details of In-service e-Learning Environmental Education Content for Elementary School Teachers

Section		Title	Content	Hours
Part 1 Basics of environmental education		1. Introduction of Environmental education	▪ Characters and problems of environmental problems ▪ Relationship between human beings and the environment	2
		2. History of environmental education	▪ History of Korea's environmental education ▪ History of international environmental education	2
		3. Objectives and content of environmental education	▪ Objectives and targets of environmental education ▪ Content of environmental education	2
		4. Teaching/Learning method for environmental education	▪ Major teaching/learning method for environmental education	2
		5. Evaluation of environmental education	▪ Major evaluation methods of environmental education	2
Part 2 Understanding of the Environment	Ecosystem	6. Concept of the Ecosystem 7. Interdependency of the Ecosystem	▪ Concept, functions, and components of the ecosystem ▪ Components and interrelations among them	2
	Water	8. Introduction to Water 9. Water, Source of Life 10. Water Shortage	▪ Circulation and role of water ▪ State of water shortage, cause and countermeasures	5
	Air	11. Introduction to Air 12. Indoor Air Pollution 13. Global Warming	▪ Damage of indoor air pollution, cause and countermeasures ▪ Damage of global warming, cause and countermeasures	5
	Soil	14. Introduction to Soil 15. Story of Living Creatures in Soil 16. Soil Pollution	▪ Understanding and protection of living creatures in soil ▪ Damage of soil pollution, cause and countermeasures	5
	Natural Resources and Energy	17. Introduction to Natural Resources/Energy 18. Story of Fossil Energy Sources 19. Rational Use of Energy	▪ Creation and preservation of fossil energy sources ▪ Ways to use energy rationally	5
	Plants and Animal	20. Introduction to Plants and Animals 21. Story of Wild Flowers 22. Importance of Forest 23. Sufferings of Migratory Birds	▪ Extinct wild flowers, cause and countermeasures ▪ What we get from forest and how we protect it ▪ Why migratory birds are disappearing	8
	History of the Environment	24. Destruction of the environment – Easter Island	▪ Story of Easter Island ▪ Relationship between civilization and the environment	2
	Ethics of the Environment	25. Nature in court	▪ Can rabbits sue? ▪ Environmental ethics and animal rights	2
	Psychology of the Environment	26. Interesting environmental psychology	▪ Interesting story of psychology ▪ Case studies of environmental psychology	2
	Policies of the Environment	27. The right environmental policies	▪ Korea's environmental policies ▪ International environmental policies	2
Part 3 Strategies for Environmental Education at School		29. Strategic Models for Environmental Education at Elementary Schools	▪ Strategies for environmental education in elementary school	2
		30. Curricula and Environmental Education at Elementary Schools	▪ Environmental education through curricula at elementary schools	4
		31. Discretionary Activities and Environmental Education at Elementary Schools	▪ Environmental education through discretionary activities in elementary schools	4
		32. Special Activities and	▪ Environmental education through special	4
-		33. Individual Tasks	-	2
-		34. Evaluation	-	2
			Total	66

Table 4. Details of In-service e-Learning Environmental Education Content for Middle School Teachers

Section		Title	Content	Hours
Part 1 Basics of environmental education		1. Introduction of Environmental education	▪ Cause of environmental issue ? environmental issue ? outcome ? resolution ? need for environmental education	2
		2. History of environmental education	▪ History of environmental education in Republic of Korea ▪ History of international environmental education	2
		3. Objectives and content of environmental education	▪ Objectives and targets of environmental education ▪ Scope and Content of environmental education	2
		4. Teaching/Learning method for environmental education	▪ Educational method according to environmental education content	2
		5. Evaluation of environmental education	▪ Evaluation according to teaching/learning method	2
Part 2 Understanding of the Environment	Ecosystem	6. Understanding of the ecosystem 7. Looking for tideland 8. Trip to the Upo swamp	▪ Ecosystem in general ▪ Advantages and preservation of tideland ▪ Value of the Upo swamp	5
	Water	9. What is water? 10. Purification of water 11. Red tide	▪ Water in general ▪ Purification process of water ▪ Understanding of red tide	5
	Air	12. What is air? 13. Ozone layer, the shield from ultra violet rays 14. Acid rain 15. Understanding of smog	▪ Air in general ▪ Problems and countermeasures of ozone layer ▪ Problems and countermeasures of acid rain ▪ Problems and countermeasures of smog	5
	Soil	16. What is soil? 17. Soil erosion 18. Soil pollution and countermeasures	▪ Soil in general ▪ Problems and countermeasures of soil erosion ▪ Problems and countermeasures of soil pollution	5
	Natural Resources and Energy	19. What are natural resources and energy? 20.Eco-friendly consumption 21. Domestic Waste	▪ Natural resources/energy in general ▪ Ways of green consumption ▪ Understanding of domestic waste treatment	5
	Plants and Animal	22. What are plants and animals? 23. Our fields and grass 24. Beautiful migratory birds	▪ Plants and animals in general ▪ Beautiful fields and grass of Korea ▪ Beautiful migratory birds of Korea	5
	History of the Environment	28. Destruction of the environment – Easter Island	▪ Story of Easter Island ▪ Relationship between civilization and the environment	2
	Ethics of the Environment	25. Nature in court	▪ Can rabbits sue? ▪ Environmental ethics and animal rights	2
	Policies of the Environment	26. The right environmental policies	▪ Tragedy of the Commons ▪ Korea's environmental policies ▪ International environmental policies	2
	Psychology of the Environment	27.Interesting environmental psychology	▪ Interesting story of psychology ▪ Environmental psychology in general ▪ Case studies of environmental psychology	2
Part 3 Strategies for Environmental Education at School		29. Strategic Models for Environmental Education at Middle Schools	▪ Strategies for environmental education at middle school	2
		30. Curricula and Environmental Education at Middle Schools	▪ Environmental education through curricula at middle schools	4
		31. Discretionary Activities and Environmental Education at Middle Schools	▪ Environmental education through discretionary activities in middle schools	4
		32. Special Activities and Environmental Education at Middle Schools	▪ Environmental education through special activities in middle schools	4
-		33. Individual Tasks	-	2
-		34. Evaluation	-	2
			Total	66

Table 5. Details of In-service e-Learning Environmental Education Content for High School Teachers

Section		Title	Content	Hours
Part 1 Basics of environmental education		1. Introduction of Environmental education	▪ Cause of environmental issue ? environmental issue ? outcome ? resolution ? need for environmental education	2
		2. History of environmental education	▪ History of environmental education in Republic of Korea ▪ History of international environmental education	2
		3. Objective and content of environmental education	▪ Objective and targets of environmental education ▪ Scope and Content of environmental education	2
		4. Teaching/Learning method for environmental education	▪ Educational method according to environmental education content	2
		5. Evaluation of environmental education	▪ Evaluation according to teaching/learning method	2
Part 2 Understanding of the Environment	Ecosystem	6. Understanding of the ecosystem 7. Trip to the Baekdu mountain range 8. Exploration of the Upo swamp	▪ Ecosystem in general ▪ Understanding, damage and preservation of the Baekdu mountain range ▪ Ecosystem, damage and preservation of the Upo swamp	5
	Water	9. Understanding of water 10. Sewage treatment 11. Understanding of bio-accumulation	▪ Water in general ▪ Understanding of sewage treatment ▪ Damage, causes and countermeasures of bio-accumulation	5
	Air	12. Understanding of air 13. Understanding of noise 14. Understanding of El Niño 15. Understanding of yellow dust	▪ Air in general ▪ Problems and countermeasures of noise ▪ Problems and countermeasures of El Niño ▪ Problems and countermeasures of yellow dust	5
	Soil	16. Understanding of soil 17. Soil pollution and countermeasures 18. Preservation of soil resource	▪ Soil in genera ▪ Problems and countermeasures of soil pollution ▪ Ways to prevent soil resources	5
	Natural Resources and Energy	19. What are natural resources and energy? 20. Understanding of industrial waste 21. Solutions to energy problems	▪ Natural resources/energy in general ▪ Treatment of industrial waste ▪ Solutions to energy problems	5
	Plants and Animal	22. Understanding of living creatures 23. The giving tree 24. Looking for extinct species	▪ Living creatures in general ▪ Extinct trees and countermeasures ▪ Understanding and preservation of extinct species	5
	History of the Environment	28. Story of Easter Island	▪ Story of Easter Island ▪ Relationship between civilization and the environment	2
	Ethics of the Environment	25. Understanding of nature's rights	▪ Environmental ethics ▪ Suits by the nature on its rights	2
	Policies of the Environment	26. Understanding of environmental policies	▪ Korea's environmental policies ▪ International environmental policies	2
	Psychology of the Environment	27. Understanding of environmental psychology	▪ Environmental psychology in general ▪ Case studies of environmental psychology	2
Part 3 Strategies for Environmental Education at School		29. Strategic Models for Environmental Education at High Schools	▪ Strategies for environmental education at high school	2
		30. Curricula and Environmental Education at High Schools	▪ Environmental education through curricula in high schools	4
		31. Discretionary Activities and Environmental Education at High Schools	▪ Environmental education through discretionary activities in high schools	4
		32. Special Activities and Environmental Education at High Schools	▪ Environmental education through special activities in high schools	4
-		33. Individual Tasks	-	2
-		34. Evaluation	-	2
			Total	66

curricula at each level of the schools are presented based on the kind of content that should have more weight or be taught at a certain level of school.

Part 2 - Understanding of the Environment includes the content that has been developed with different themes at each level of the schools, according to various groupings including "the ecosystem", "water", "air", "soil", "natural resources and energy", "plants and animals," all from the natural science perspective. From the human and social science perspectives, this part has four categories:

1. Environmental Ethics which deals with ethics and lawsuits in relation to the environment,

2. Environmental Policies which deal with domestic and international environmental policies on a basis of the Tragedy of the Commons,

3. Environmental Psychology which includes theories and cases related to environmental psychology, and

4. The History of the Environment which deals with the relationship between civilization and the environment, focusing on the story of Chile's Easter Island.

Part 3 - Strategies for Environmental Education at School consists of four categories:

1. Strategic Models for Environmental Education, which are general models of strategies for environmental education,

2. School Education and Environmental Education,

3. Discretionary Activities and Environmental Education, and

4. Special Activities and Environmental Education.

In total, there are 66 hours of education including individual tasks (2 hrs) and evaluation (2 hrs), complying with in-service education hours (more than 60 hrs).

Design and Development of e-Learning Content

Based on the results from the requirement analysis, planning and conceptual design stages, the research group designed content screens and storyboards. Figure 2 is an example of the developed storyboards. The figures illustrate "Understanding El Niño" [of Part 2, Understanding the environment] for high schools. On the left, it shows the teaching-learning stages of introduction, content, summary and evaluation and further studies.

The content part presents major content for learning. At the bottom, there are buttons to click on: a button that shows the whole leEEC index for school teachers, 'previous/next' buttons and a 'close' button that closes the current content. Content for learning and major content are placed at the center of the screen.

Fig. 2 Examples of the developed storyboards

Based on the storyboards developed from the e-Learning content design stage, the researchers commissioned the development of leEEC to professional content developers. During the process, researchers and experts were continuously examining the content. Figure 3 demonstrates the developed content.

Fig. 3 Examples of the developed leEEC

Evaluation of In-service e-Learning Environmental Education Contents for Elementary, Middle and High School Teachers

Based on evaluation criteria of leEEC suggested in the research methods, the research group commissioned evaluation to eight experts in environmental education of each school level. Each expert rated each question from 1 (not relevant at all) to 5 (highly relevant). Below are the results of the evaluation, focusing on frequency, mean and standard deviation of scores for each question in the big category.

Table 6. The results of the evaluation of IeEEC for elementary, middle and high school teachers

Category		Elementary School		Middle School		High School	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Overall Content	Relevance of content	4.25	0.46	4.50	0.53	4.25	0.46
	Systematization of content	4.50	0.53	4.63	0.52	4.38	0.52
	Difficulty of content	3.75	0.46	3.75	0.46	3.75	0.46
	Difficulty of terms	3.75	0.46	3.88	0.64	3.88	0.35
	Fun of content	3.88	0.64	3.63	0.52	3.75	0.46
	Allotment of Hours	3.63	0.52	3.38	0.52	3.50	0.53
Development and structures of content	Introduction to learning	4.38	0.53	4.50	0.53	4.38	0.52
	Content for learning	4.50	0.53	4.13	0.35	4.13	0.35
	Summary and Evaluation	4.50	0.53	4.63	0.52	4.75	0.46
	Further Studies	4.63	0.52	4.50	0.52	4.88	0.35
Total		4.18	0.52	4.15	0.51	4.16	0.45

The mean for content for elementary school teachers is highest at 4.18. In the category of overall content, the mean of systematization of content is highest at 4.50 while both difficulty of content and terms are comparatively low at 3.75 and allotment of hours is lowest at 3.64. Looking at the development and structures of content, further studies stands at 4.63, both content of learning, summary and evaluation, 4.50 and introduction to learning 4.38 (see Table 6).

The mean of content for middle school teachers is relatively high at 4.15. In the category of overall content, the mean of systematization of content is highest at 4.63 while allotment of hours is lowest at 3.38. In the category of the development and structures of content, summary and evaluation is 4.63 while introduction to learning is 4.50, further studies, 4.50, and content for learning, 4.13.

The mean of content for high school teachers stands at 4.16. Looking at overall content, the mean of systematization of content is highest at 4.38 while allotment of hours is lowest at 3.50. In the development and structures of content, the mean of further studies is 4.88, while summary and evaluation, 4.75, introduction to learning, 4.38 and content for learning, 4.13.

In the evaluation, the means of the big categories all score highly among the different levels of the schools, ranging from 4.15-4.18. In overall content, the means of systematization of content are highest while difficulty of content, difficulty of terms, and relevancy of content and allotment of hours are relatively low. In the category of the development and structures of content, the mean of content for learning is comparatively low.

Therefore, it is necessary to modify the allotment of hours and difficulties of content and terms in developing IeEEC for elementary, middle and high school teachers. Regarding the development and structures of content, content for learning needs revising.

Summary and Recommendations

This study closely examined the objectives and targets of environmental education, systems of content, and environmental education for different groups. It was followed by collection and analysis of IeEEC, provided both online and offline, for local and overseas elementary, middle and high school teachers. For the development of content, the researchers commissioned detailed examination to experts to confirm validity. Literature review and hosting of expert forums were also done for this purpose. In addition, to enhance interest, and relevance fairytale writers were commissioned to develop easier and more valid scenarios and narrations of IeEEC for elementary, middle and high school teachers.

By reviewing related literature on local and international environmental education, the research group established the ultimate objective of in-service e-Learning education as "enhancing professionalism of elementary, middle and high school teachers in environmental education". Based on the problems faced by Korea and the systematic processes for developing and designing IeEEC, the group developed IeEEC for elementary, middle and high school teachers. The developed content was intended for 66 hours of teaching and it had three sections: i) Basics of Environmental Education, ii) Understanding of the Environment, and iii) Strategies for Environmental Education at School. Since the content has been developed based on SCROM, it is expected to have re-usability, relevance, compatibility and durability.

Recommendations for applying the content developed in this study and further research are as follows:

First, the developed content should be actively promoted and provided both online and offline so elementary, middle and high school teachers may fully utilize them. To this end, the website of the Ministry of Environment and e-Learning training centers of universities of education should be used. Since content requires interaction not only between learners of the content but also between learners and operators, additional administrative and financial support should be provided.

Second, to reinvigorate training for elementary, middle and high school teachers at the governmental or ministerial level, there should be a system that can accumulate and systematically provide a database of existing content as well as the content developed from this study. To this end, the Ministry of Environment is required to build a U (Ubiquitous)-portal site that can systematically provide content services for not only learners but also for teachers.

Third, this study focuses on the development of IeEEC for elementary, middle and high school teachers. Further studies are needed to develop content for environmental educators of universities and for adults.

References

Seo, W.S,, Lee, Y. H., Jyung, C. Y., Na, S. I., Kim, J. M.,Lee, J. H. (2005). Development of the e-Learning Contents for Environmental Education of Elementary School Students and Teachers to Keep the Clean and Blue Earth. *The Department of Agricultural Education, Human Resources Development, 37* (4), 243-274

Seo, W.S,, Lee, Y. H., Jyung, C. Y., Na, S. I., Kim, J. M.,Lee, J. H. (2006). Development of e-learning environmental education content for elementary school teachers. *The Department of Agricultural Education, Human Resources Development, 38* (3), 195-220.

Engleson, D.C. & Yokers, D. H. (1994). *A guide to curriculum planning in environmental education.* Wisconsin.

NAAEE. (1999). *Excellence in Environmental Education Guidelines for Learning (K-12)*. Rock Spring, Georgia, USA.

NEEAC. (1996). *Report Assessing Environmental Education in the U. S*. Washing D.C.: EPA.

NSW Department of Education. (1993). *Environmental Education : Curriculum Statement K-12*. Australia.

Palmer. J. (1998). *Environmental Education in the 21st Century: Theory, practice, Progress and promise*. London: Routledge.

Roth. R. (1998). Environmental Literacy: Its Roots, Evolution, and Directions in the 1990s. *EE Reference Collection. Michigan*: NCEET.

Shin, Donghee S. (1999). Environmental earth science education for the preservice teachers in the Republic of Korea. *Journal of Environmental Education, 27*(2).

The Cultivation and Processing of Haskap in Hokkaido, Northern Japan

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INTRODUCTION

Haskap (*Lonicera caerulea L*) is an edible blue honeysuckle (Fig.1). It is called in various names - Haskap Berry, Blue Honeysuckle, Hascup, Haskappu, Honeyberry TM, Sweet Berry Honeysuckle, or Swamp Fly Honeysuckle.

Figure 1. Haskap (Lonica caerulea)

This fruit is native to Hokkaido, the northernmost island of Japan. The Ainu, the original indigenous people of Hokkaido, have promoted Haskap for many years as a health food and as the secret Ainu medicine for achieving longevity.

Haskap has many significant attributes that should make it a popular crop among growers. It is extremely hard (Zone 0 hardiness). It can withstand wet soil and may be suitable where other crops cannot be grown. Haskap bushes are best planted in the fall and may yield fruit in the first year after

planting. They mature quickly, and by the third or fourth year, they may already be producing four to six kilograms of fruits per bush.

People in Japan have long valued the medicinal effects of Haskap, with one juice product marketed as the "golden remedy for eternal youth and longevity." The fruits are high in vitamin C and antioxidants. A sizable market exists for Haskap. Although the fruit is highly valued in Japan, its traditional growing areas are being reduced by population growth.

Haskap berries can be processed for food in many different ways: fresh fruit (some varieties), candy, chewing gum, jam, jelly, gelatine, ice cream, yogurt, pies, fruit cake, tarts, berry bars, juice, juice-concentrate, soda pop, wine, tea, canned fruit, frozen fruit, and medicinal uses like as an antioxidant or a health food. Total Japanese production of the fruit is about 100 million tons a year. In Japan, yield from mature bushes of 5 to 6 years of age is about 1kg per bush.

Breeding and processing for increased health value could further augment the acceptance of Haskap by consumers. Beneficial compounds have been identified in Haskap berries as the characterization and quantification of anthocyanins and polyphenols [1]. But free radicals of Haskap have not been directly investigated.

The Electron Spin Resonance (ESR) method has been employed as a method for detecting free radicals in food. However, the analysis of the ESR signal is not an easy task. Its application to food has been limited [2, 3, 4]. Using ESR method, the existence of free radicals in pepper [5], wheat flour [6] and a Ginseng [7] has been successfully revealed. In the present study the same methods to show the existence of free radicals in Haskap berries was used.

METHODOLOGY

Materials

The specimens in the study are lyophilized Haskap. The 300 mg specimens were sealed in an EPR sample tube (suprasil, 99.99% purity: Jeol) under either vacuum or air.

ESR spectroscopy

ESR measurements were carried out using a spectrometer (Jeol, JES-FE1XG). All the ESR spectra were recorded at the X-band (9.3 GHz). For the careful detection of all the radical species in the specimen, two kinds of field sweep, 250 ± 250 and 320 ± 100 mT was employed. Magnetic field modulation and demodulation were operated at 100 kHz, and hence all our ESR spectra were recorded in the first harmonic mode. The modulation width was 0.3 mT. All the ESR measurements were made at room temperature ca. 20 C. The g-values were determined by a DPPH powder standard using the dual-mode cavity.

RESULTS AND DISCUSSIONS

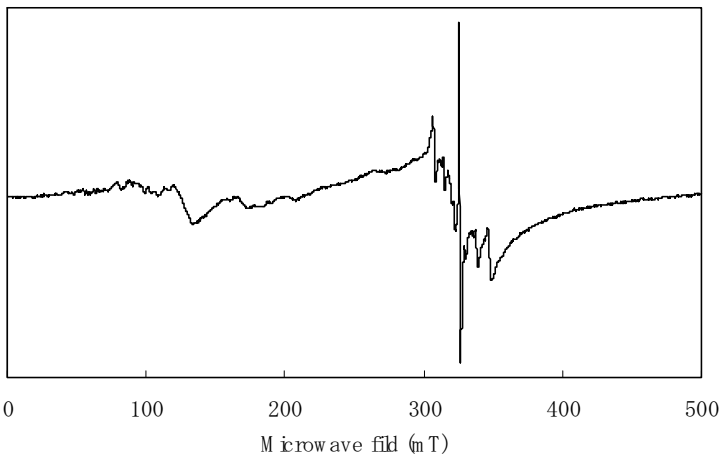
ESR spectral features of Haskap

Figure 2 shows the ESR spectrum of lyophilized Haskap. The ESR consisted of three signal components. The first, a sharp signal found at g = 1.9829, was due to the presence of organic free radicals such as plant polyphenol. The second, a huge sextet hyperfine line, is attributable to Mn2+ ion centered at g = 2.0020. The third is a Fe3+ ion g = 4.0020. To evaluate the hyperfine constant (hfc) of the Mn2+ ion, two methods were employed, either taking the summit or the maximum slope of each peak. These methods yielded the identical hfc of *ca.* 7.3 ± 0.1 mT.

ESR signal of Mn (II)

The ESR signals of plant specimens shows that the sextet pattern due to Mn (II) may be broadened by the presence of polyphenol in plant tissues. In fact, Morsy *et al.* have reported [8] that the ESR signal from Mn (II) in leaf tea indicated such a broadening in the presence of semiquinon. A similar phenomena has been observed [9] by Rhodes who summarized that the antioxidant content induced the broadening of the Mn (II) ESR signal. Therefore, a similar broadening of the Mn (II) signal due to the presence of polyphenol in Haskap would be a plausible hypothesis. According to the most recent literature, the structure of the Mn signal, besides these other factors, is strongly influenced by the degree of disturbance of Mn (II) bonding in protein complexes. This was revealed through thermal or other treatment (drying, fermentation, and smoking) with respect to the role of manganese ions in plant biosynthesis routs [8,10,11].

Figure 2. An ESR spectrum of Haskap



CONCLUSIONS

In order to promote research about Haskap, the researchers, in cooperation with commercial growers of Haskap and the food processing industry, established the Northern Japan Agricultural Research Institute in 2004. The head of the Institute is Mitsuko Ukai, a professor at Hokkaido University of Education. The chief aim of the Institute is the promotion of Hokkaido's agricultural and marine produce. The marketing strategy from 2004 to 2007 is focused on Haskap and includes cooperation with the Canadian Trade in Japan and the University of Saskatchewan.

Figure 3 shows a meeting at the Institute. In 2006, the researchers developed new products using Haskap syrup and filtrates. They also investigated several products (Fig. 4, 5, 6). Using Haskap powder (Fig. 7), a public tasting test was held at Tomakomai in Hokkaido, in 2006. The taste tests (Fig. 8, 9) revealed a high acceptance rate among the Japanese public for processed Haskap products. The ultimate goal is to educate the public as to the beneficial health effects of Haskap and develop commercial opportunities with both commercial growers and the food processing industry.

Figure 3. Meeting at the Northern Japan Agricultural Research Institute

Figure 4. Haskap noodle

Figure 5. Sweatend bean paste (with Haskap powder) cake

Figure 6. Rolled sushi made from rice with Haskap juice and salted Haskap (left). Rolled sushi made from rice with Haskap juice added to it (right).

Figure 7. Powdered Haskap

Figure 8. Trial products using powdered Haskap

Figure 9. Public tasting event

NOTES

1. A. Chaovanalikit, M. Thompson, R. Wrolstad., J. of Agric. and Food Chem. 52(4): (2004)848-852.

2. EN 1786(1996)

3. EN 1787 (1996)

4. EN 1787 (2000)

5. M. Ukai, Y. Shimoyama, Radiation Physics and Chemistry 71, (2004)177-180.

6. M. Ukai, Y. Shimoyama, Appl. Magn. Reson, 29 (2005) 315-324.

7. H. Nakamura, M. Ukai, Y. Shimoyama, Spectrochimica Acta A63 (2006) 883-887.

8. M. A. Morsy, M. M. Khaled, Spectrochim. Acta A 58 (2002) 1271–1277.

9. C. J. Rhodes, Annu. Rep. Prog. Chem., Sect. C, 100 (2004) 149-193.

10. M. Polovka, V. Brezova, A. Stasko, Biophys. Chem. 106 (2003) 39–56.

11. A. Jezierski, F. Czechows, M. Jerzykiewicz, I. Golonka, J. Drozd, E. Bylinska, Spectrochim. Acta A 58 (2002) 1293–1300.

Growing Crops in Mine-Tailed Affected Area Ameliorated with Organic Materials: An Attempt

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INTRODUCTION

The Philippines is considered one of the highly mineralized countries of the world. Its mining enterprise has contributed to its own share of environmental problems that needs immediate consideration. The common problem associated with these mining operations is the disposal of mineral wastes. Mine tailings pose pollution hazards and the favorable value of the natural environment deteriorates. These wastes cover fertile farmlands making them unproductive (Lirio and Mercado, 1980). Walker (1978) said that acidity, lack of nutrient elements and low soil oxygen levels are also problems in these areas. The Bureau of Soils (1978) stated that mine tailings contain high amounts of heavy metals but low in nutrient element essential for healthy development of plants. Mining may cause environmental issues ranging from waste rock and tailings disposal, land disturbance, dust and noise, to water use and pollution. If not managed well, any of this could affect the health and livelihood of the poor and vulnerable groups living near the mining operations (Daladag, 1987).

Mineral mining companies in Benguet produce thousands of tons of mine tailings annually. The solid component of mine tailing is contained in tailing dams constructed for the purpose. The liquid component, however, is discharged into the river systems. Abandoned tailing dams of mining areas pose hazard and they become eyesores. Some of these dams are found in Benguet, which include the dams of Philex Mine Corporation. (Elegado, 1981).

The Philex Mining Corporation mine site is located at the southern tip of Central Cordillera, straddling within the communities of Tuba and Itogon, Benguet. It is about 17 aerial kilometers south-southeast of Baguio City and lies at an elevation of 1,500 meters above the sea level. Land access from

Baguio City is via 32 kilometer well-paved road (Philex Mining Corporation, 1985).

Philex Mines Corporation, located at Pacdal, Tuba, Benguet is one of the biggest gold producers in the entire Philippines. This mine adopts the downstream method of building up its tailing ponds. This method utilizes the coarse portion of the tailings themselves to build up the dam body. The tailing ponds are located at Sitio Banget and Sitio Sal-angan of Ampucao, Itogon, Benguet. However, pond no. 1 which is located at Sal-angan is not functioning at present and it is under rehabilitation process. The use of tailings pond number 1 (located at Sal-angan, Itogon, Benguet) was discontinued in the early part of 1992 due to the heavy scouring at its downstream portion (Almogela, 1994). Apparently, the incident was an offshoot of the 1990 earthquake when part of the dam's drainage was damaged. Were it not for the immediate availability of dam 3, the corporation could have been ordered to cease to operate. This is due to the possibility that the tailings pond will leak with a discharge of about 26,750 tons per day (9.8M tons/ year) of waste sediments (Pandosen, 1996).

The study was conducted to find out the effects of the organic amelioration of the tailings pond to the selected different test plants such as green onions, pechay, peanut, potato and vetiver grass. Specifically, the study aimed to:

1. Determine the performance of selected plants grown in mine-tailed areas ameliorated with organic fertilizers; and

2. Determine some physical, chemical properties and heavy metal content of the tailings with organic fertilizer before and after the application of organic fertilizer.

Mining is necessary to obtain minerals (Hore - Lacy, 1978). However, waste from mines must be disposed properly to avoid environmental damages. Generally, all mine wastes areas are deficient of the amount of essential nutrients needed by plants (Bureau of Soils, 1978).

There is a need to look for alternative livelihood of employees and those families who are affected by the impending closure of the mining corporation. One alternative to decrease the amount of environmental degradation brought about by the presence of mine tailings is using the potentials of the tailing ponds as agricultural areas. This was conducted to see whether the five selected crops planted can thrive in mine-tailed areas and can be of importance to the local community. This study analyzes the possibility of growing plants that may have economic value to the community. Knowing the best suited plants that can thrive in a mine tailed area, can inform the people, on what plants are good to cultivate in tailing ponds. In one way or another, this study helps the people to transform the tailings into a more productive resource. The study serves as a source of

information in transforming mine tailings covered areas into a potential agricultural land.

MATERIALS AND METHODS

The materials used in the study were as follows: fertilizers - Giant 8-8-8, chicken dung, compost; fertilizer materials - 14-14-14 or complete fertilizer, urea (46-0-0), 16-20-0 or solophos (0-18-0), and muriate of potash (0-0-60); test plants - green onion, peanut, pechay, potato and vetiver grass; and garden tools - grab hoes, bamboos and wires.

An area of 150 m^2 was thoroughly prepared at the dam site identified prior to planting. There were only two set-ups for the study, the organic fertilizer ameliorated and non-ameliorated treatment. Sixty plots were prepared, with each plot measuring 0.5m x 5 m. The plots were divided into three blocks to represent the three replicates. Each block had 20 plots where 4 plots are allotted for every test plant. The first two plots are free of organic ameliorants and the remaining two were ameliorated with organic fertilizer like compost, chicken dung and Giant 8-8-8.

The computed amounts of organic fertilizer were mixed thoroughly prior to planting. Application of the recommended rate of N-P205-K20 per hectare for each plant was followed. The fertilizers used for the maintenance of the plants were 14-14-14, urea, solophos, and muriate of potash.

The following test plants were used in the conduct of the trial:

C_1 = Green onion, C_2 = Peanut, C_3 = Pechay, C_4 = Potato, and C_5 = Vetiver Grass

Green onion. Onion leeks were cut into uniform sizes of 17 cm. These were planted in two columns and each plot allotted contained 20 onion leeks. The distances between the rows measured 15cm and 15cm between hills. This was done in all the replicates.

Peanut. Peanut seeds were used as planting material which was planted alternately in two columns per plot. Each hole contained three seeds with a depth of 3-4 cm. On the fourth, muriate of potash (66.67 kg/ha), sobphos (222.22 kg/ha) and urea (65.22 kg/ha) were applied as maintenance fertilizers.

Pechay. Pechay seeds were used as planting material which were spread on the plot surface and covered with a thin layer of grass to prevent them from being washed away. The maintenance fertilizers used were urea (391.30 kg/ha) and 14-14-14 (428.57 kg/ha) applied fifteen days after planting.

Potato. Planting of potato was done in two columns per plot. One tuber was allotted to every hole. After a month, 14-14-14 (12,000kg/ha) was applied as maintenance fertilizer.

Vetiver Grass. The vetiver grasses were cut uniformly with a height of 10 inches from roots. These were planted in plots with a distance of 20 cm between rows and 20 cm between hills.

When the test plants started to germinate, the measurement for the weekly growth increment was obtained. Representatives of each plot was determined by random selection of ten plant stands and marked by a stick beside them to ensure consistency. Along with the application of maintenance, hilling up and weeding were done.

The harvesting of the crop was done through the conventional method. The total yields were determined by weighing its marketable and non-marketable yield except for Vetiver grass which was obtained by taking the biomass.

The performances of the different plants in the experimental set-up were determined by measuring the total yield. This was the total weight of marketable and non marketable plant per plot. The usual practice of harvesting of the said plants was used.

The characterization of soil was done only in the experimental set-up ameliorated with organic fertilizer. Two sets of soil samples were collected. The first set of soil sample was collected from the soil tailings before the amelioration of organic fertilizer. The second set of soil sample was from plots ameliorated with organic fertilizers and was collected after harvesting of the crops. The physical, chemical and heavy metals were analyzed following the PCARRD Standard Procedures of Analysis for Soil, Plant Tissue, Water and Fertilizer.

RESULTS AND DISCUSSION

A. **Agronomic Parameters**

1. Total Yield

Green onions. Table 1 shows the yield response of green onions planted in mine-tailed areas ameliorated with organic fertilizer mixtures of compost (20 tons/ha), chicken dung (5 tons/ha) and Giant 8-8-8 (1000 kg/ha) and the control or without organic fertilizer amelioration. The mean yield of green onions planted in plots ameliorated with organic fertilizers was 1.82 kg/plot, while 0.97 kg/plot was the mean yield in plots without organic fertilizer amelioration. Statistical data showed that application of organic fertilizer did not significantly affect the yield of green onions on the two treatments. However, an increase of 87.63 % total yield was noted from

mine-tailed plots ameliorated with organic fertilizers. They were observed to have more developed roots compared to plots without organic amelioration. Comparison of harvested green onions of both treatments is shown in Plate 2. These observations corroborates with the study of Biggs et al. (1989) which states that addition of organic materials in poor soils stimulates the development of plants. Brady and Weil (2002) added that organic fertilizers contain humic materials which have substantial amounts of nutrient elements. These nutrients are very essential for the guaranteed growth of vegetative crops.

Table 1. Yield performance of green onions (kg/2.5 m^2) planted in mine tailed areas

TREATMENT	MEAN (kg/plot)	% INCREASE
With organic fertilizer	1.82[a]	87.62
Without organic fertilizer	0.97[a]	

Means with common letter are not significantly different at 5 % level DMRT

Plate 1. Green onions stand in plots applied with organic fertilizer showed better performance than the untreated plots.

Plate 2. Green onion harvested in plots without organic fertilizers gave lesser yield compared with those from plots applied with organic fertilizer (87.63%)

Peanut. Significant yield response of peanuts was obtained in areas ameliorated with fertilizers using mixtures of compost (20 tons/ha), chicken dung (5 tons/ha) and Giant 8-8-8 (1000 kg/ha), as shown in Table 2. Application of organic fertilizers gave significant increase of 175% in mine-tailed areas applied with organic fertilizers over the control plots. Heavier and more nuts were harvested from plots applied with mixtures of organic fertilizers compared to the control (Plate 4). Plants coming from the organic ameliorated soil showed taller stalk and had more nuts per stalk compared to the peanuts that are planted in soil without organic amelioration (Plate 4). The increase in yield in these plots could be attributed to the total effects of the different organic fertilizers in crops.

In support for these observations, Jones (2003) said that organic materials contain nutrient elements which are very useful for the growth and development of crops. These organic materials contain the basic elements which are nitrogen, phosphorus, potassium.

Table 2. Yield of peanut (kg/2.5 m^2) planted in mine-tailed areas from both the two treatments.

TREATMENT	MEAN (kg/plot)	% INCREASE
With organic fertilizer	851.23[a]	175
Without organic fertilizer	309.47[a]	

Means with common letter are not significantly different at 5 % level DMRT

Plate 3. Better growth performance of peanut plants in plots applied with organic and without organic fertilizer

Plate 4. Comparison on the yield of peanuts obtained from plots ameliorated with organic fertilizers and the control. Yield was obtained from those plots applied with the recommended rates of compost, chicken manure and Giant 8-8-8.

Plate 5. Peanut stalks 10 weeks after planting showing the plants grown in soil with organic fertilizer having a longer stalk and more nut formed over the other treatment.

Pechay. Table 3 shows the effect of mixtures of compost (20 tons/ha), chicken dung (5 tons/ha) and Giant 8-8-8 (1000 kg/ha) on the yield of pechay. Organic ameliorants tremendously increased the yield of pechay (351.67 %) on the treated plots as compared to those plants grown without organic matter application. Statistically the yield of pechay grown in organic-ameliorated soil is higher than that of the pechay grown in plot without organic amelioration.

Observations made at harvest showed that plants in treated plots were heavier and healthier than those obtained from the control plots (Plate 7). The findings confirmed with the statement of Elegado (1981) saying that application of farm and animal manure produced better growth and yield of crops in areas affected with mine tailings.

The finding confirms the study conducted by Laurean (1987) that organic fertilizer is as effective as chemical fertilizers in increasing crop yields. It contains humus, which has substantial amount of nutrient elements. Plants nurtured with organic fertilizers are healthier and more resistant to pest and diseases. Lardizabal (1981) added that areas covered by mine tailings could be converted to productive farms if organic fertilizers such as chicken dung and decomposed plant material are applied to increase organic matter, N, P, K, and microbial contents of the soil. A study by Kelly and Thompson (1979), stated that sugar beets grow in soil that require the application of manure at the rate of 10-15 tons/acre and a fertilizer application supplying 50-60 tons of both nitrogen and potassium nitrate and 100 lbs/acre of 205 of P gives a maximum yield. In 1977, Scholey reported that it is possible only to grow crops on mine tailings as long as additional soil, fertilizer, and reasonable care will be given.

Table 3. Yield of pechay (kg/2.5 m^2) planted in mine-tailed areas.

TREATMENT	MEAN (kg/plot)	% INCREASE
With organic fertilizer	2.17[a]	351.67
Without organic fertilizer	0.06[b]	

Means with common letter are not significantly different at 5 % level DMRT

Plate 6. Growth of pechay plants in plots applied with organic fertilizer and plots without organic fertilizer.

Plate 7. Comparison between pechay plants in plots applied with mixture of compost (20 tons/ha), chicken manure (5 tons/ha) and Giant 8-8-8 (1000 kg/ha).

Potato. The response of potato planted in mine-tailed plots ameliorated with organic fertilizers is shown in Table 4. Application of organic fertilizer consisted of compost (20 tons/ha), chicken dung (5 tons/ha) and Giant 8-8-8 (1000 kg/ha) did not significantly affect the yield of potato. However, an increase of 143.67 % was obtained from the yield of potato in mine-tailed area over the potatoes grown in soil without organic matter. This shows that organic fertilizer application can increase the yield of potato in mine-tailed areas.

The researchers had observed that potato grown in soil with organic matter produce more tubers than those potatoes harvested from plots without organic fertilizer. These observations can be seen on Plate 9. Carew and Work (1955) confirmed the results of this study saying that potatoes like any other crops, need fertilizers to supply their nutritional requirements.

Table 4. Yield of potato (kg/2.5 m^2) planted in mine-tailed areas.

TREATMENT	MEAN (kg/plot)	% INCREASE
With organic fertilizer	1.73[a]	143.67
Without organic fertilizer	0.71[b]	

Means with common letter are not significantly different at 5 % level DMRT

Plate 8. Growth of potato plants in plots applied with organic fertilizer and potato plants showing wilted leaves eight weeks after planting.

Plate 9. Comparison between the yields produced by potatoes planted in soil without the application of organic fertilizers.

Vetiver Grass. Table 5 shows the performance of Vetiver grass in terms of biomass production. Organic fertilizers applied to plots consisted of chicken dung, Giant 8-8-8 and compost. The biomass of vetiver grass planted in the soil with organic fertilizers was 65.52 % higher than that of the vetiver grass grown in the soil without organic fertilizer application. Application of organic fertilizer of the soil significantly affected the yield of the Vetiver grass. Vetiver harvested in the soil with organic amelioration had more biomass than that of control, which had no organic amelioration (Plate 11). These findings confirm the findings of Lardizabal (1981), saying that production of quality crops is possible only if tailings are supplied with commercial or organic fertilizer which can give the proper elements needed by plants. The researchers observed during harvest that the vetiver grass planted on plots with organic matter produced more stalks, were bushier and had more developed roots than those planted on plots without organic matter amelioration.

Table 5. Biomass of vetiver grass (kg/2.5 m^2) planted in mine-tailed areas.

TREATMENT	MEAN (kg/plot)	% INCREASE
With organic fertilizer	0.48[a]	65.52
Without organic fertilizer	0.29[b]	

Means with common letter are not significantly different at 5 % level DMRT

Plate 10. Growth of vetiver grass in plots applied with organic fertilizer and plots without organic fertilizer three weeks after planting.

Plate 11. Biomass production of Vetiver grass planted in both mine-tailed areas applied with different organic fertilizers and those without.

Soil Analysis

1. Physical Characteristics

Table 6 shows the physical properties of the soil before and after the organic fertilizer amelioration. Chicken dung, Giant 8-8-8 and compost were mixed together to compose the organic matter amelioration treatment. Plate 12 shows the farm set up before the application of organic amelioration. Plate 13 is the photograph representation of the farm set up after the application of organic fertilizer amelioration.

Organic matter has profound effect on soil physical condition. Its influence on the soil aggregation resulted to a better soil structure, aeration, water holding parity, infiltration and permeability (Licudine, 1987).

Table 6. Initial and final bulk density and percent pore space of the soil ameliorated with organic fertilizer.

TREATMENT	BEFORE	AFTER
Bulk density, g/cc	1.46	1.22
Pore space, %	43.00	44.00

Plate 12. Farm set up before the application of organic fertilizers in the mine- tailed area.

Plate 13. Three farm set up after the application of organic fertilizers in the mine-tailed area.

Bulk Density. The bulk density of the mine-tailed areas decreased after application of organic fertilizer. Based on the Soil Science Manual, a bulk density of 1.33 g/cc and higher is considered compacted soil while below the mark is supposedly a porous soil. The bulk density of the mine tailings before the application of the organic matter was about 1.46 g/cc, which means that the soil was compact. The final bulk density was lowered to 1.22 g/cc indicating that the cultivation and application of organic fertilizers contributed to the lowering of bulk density. This was similar to the study of Jones (2003) which cited that organic matter decreases the bulk density of soils. It can occur either directly by diluting the soil with a less dense material or indirectly through greater aggregate stability. In addition, soils with 30% organic matter have low bulk densities (Anonymous, 2001). According to USDA (1996) bulk densities of several textural classes of forest soils, for sands, has 1.43 g/cc.

Porosity. The amount of pore space is determined largely by the arrangement of solid particles. If particles tend to lie close together, as in sands or compact subsoil, the total porosity is low (Biggs et al, 1989).

The percent porosity of the experimental soil ranged from 43 to 44%, indicating that the soil media was compacted. The particles tend to lie close together so the total porosity was low. This is similar to Donahue's (1997) statement that organic matter increases soil porosity. Organic matter loosens the soil which increases the amount of pore spaces. This has several important effects. As the density of the soil goes down (it becomes less compacted), the soil structure improves. This means that the sand, silt and clay particle in the soil stick together, forming aggregates as crumbs. Organic matter acts as bonding agent to bind the basic sand, silt and clay particles into soil aggregates. Soil aggregates are much larger than the basic particles; therefore, there is usually greater pore space because the larger aggregates do not fit together as well.

2. Chemical Characteristics

Bureau of Soils (1979) found out that mine tailings are devoid of NPK and contains some microelements naturally occurring in normal soils. These soils are sandy, slightly acidic and have very low water holding capacity. Another study by de Guzman (1986) stated that mine tailings also have chemical characteristics almost similar to rocks and in the forms of concentrates usually found in the host rock type.

The chemical characteristics of mine-tailed areas before and after organic fertilizer application are shown in Table 7.

Table 7. Some chemical properties of the mine-tailed area before and after organic fertilizer application

CHEMICAL PARAMETERS	BEFORE	AFTER
pH	5.4	7.2
Organic matter content (%)	0.5	3.5
Phosphorus content (ppm)	4	17
Potassium content (ppm)	228	188
Nitrogen content (ppm)	0.025	0.175

pH. The pH of the soil before the conduct of the study showed an acidic condition having a pH of 5.36. The pH was increased to 7.2 which is a neutral condition. This is shown in Table 7 above. The observation could be attributed to the higher organic matter applied increasing the soil's pH buffering capacity. The buffering capacity of a soil determines its ability to prevent pH decline. The buffer capacity of the soil refers to its ability to resist a change in acidity. Soils having greater amounts of clay and organic matter have greater buffer capacities (May, 1980). Thus the addition of high organic matter content is a method to maintain a favorable buffer capacity.

Organic Matter. An increase of 3% organic matter was obtained after the application of organic fertilizer. Organic matter can be added to the soil by various methods using green manure crops, cover crops, crop residues, animal manures, mulches and composts. In this research, animal manure, compost and commercialized organic fertilizer (Giant 8-8-8) were used. These three mixtures significantly increased the low organic matter of the soil tailings.

Nitrogen Content. Table 12 shows the increase of nitrogen content from 0.025 % to 0.175%. This is due to the organic matter added into the soil minimizing the nitrogen lost by means of leaching and denitrification and improving the physical and chemical properties of the soil. Another is that it stores and supplies such nutrients as nitrogen, phosphorous and sulfur, which are needed in the growth of plants and soil organism (USDA, 1996). The application of urea influences the increase in nitrogen content of the organic ameliorated soil. Another source for the increase of N is the application of compost, which is the most organic N source (Hue, 1991).

Phosphorous Content. Table 7 shows an increase in the concentration of the phosphorus after organic matter was applied. Water soluble phosphorous added to the fertilizers or manure goes first into the soil solution. From there, P is taken up by the plant roots or remains readily available or less readily available. Phosphate ions do not leach, as do nitrate ions, even in sandy soils. This explains the high amount of phosphorous found in the soil tailings (Anonymous, 2001). Soil organic matter plays an important role in Phosphorus availability. Ammonium-based fertilizers increase P availability (Berton, 2003). Phosphorus contents of chicken manure and compost are relatively low thus; large amounts are needed to meet the phosphorus requirement of crop (Hue, 1991). This explains the large amount used on the research experiment. Another study of Hue (1995) concluded that there

is a strong competition between plants and soils for Phosphorus in the soil solution. And the winner usually is soils. Soils contain large amounts of iron and aluminum oxides or amorphous alumina silicate clays, which tie up firmly. This explains the increase in the phosphorus content of the soil after the application of organic fertilizer.

Potassium Content. From an initial measurement of 228 ppm, the resulting amount went down to 188 ppm after the application of organic matter (Table 7). The decrease in the amount of K is attributed to the absorption of potassium from the soluble potassium pool, which is located in the top soil. This pool gets exhausted pretty quickly due to the absorption of potassium by plants and soil erosion. Jones (2003) added that most plants absorb K more than they normally need, thus, resulting to a low K content of the soil. Another thing is that sandy soils usually are K-deficient soils; the application of K is always lost trough leaching if not readily taken up by plants (Dierberger et.al., 1982).

3. Heavy Metals

Table 8 shows the heavy metal content of the mine-tailedarea before and after the game fertilizer amelioration.

Table 8. Iron and copper content of the soil ameliorated with organic fertilizer before and after planting.

HEAVY METALS	BEFORE ORGANIC FERTILIZER AMELIORATION	AFTER ORGANIC FERTILIZER AMELIORATION
COPPER (%)	2.72	2.06
IRON (%)	9.83	8.46

Copper. The copper content of the mine-tailed area before planting was 2.72%, while after harvest, the concentration of the copper declined to 2.06%. With the addition of organic matter, Cu availability can be significantly reduced (Donahue, 1997). Copper availability decreases as organic matter in the soil increases. Organic matter binds up copper tightly than any other micronutrient. This not only reduces fixation by soil minerals and leaching, but also reduces availability to crops. Organic soils, therefore, are more likely to be more deficient in copper than are mineral soils (Wong and Zhou, 2001). Another reason for the decrease in the heavy metals of the soil is its texture. Being a sandy medium, the water holding capacity is low, thus the heavy metals are leached together specially during continuous irrigation (Pandosen, 1996).

Iron. There was a decrease of 13.42% on the iron contents of the soil after harvest. A decrease of the initial measurement on iron content of the mine-tailed area as shown in Table 8 was from 9.83% down to 8.46%. This is probably because of the chelating ability of organic matter which may

unite micronutrient cat ions such as iron, zinc, copper and manganese to improve their mobility (Dierberger et.al, 1982). This ability will then decrease the amount of iron or other trace element that would be absorbed by the plants. Most of the iron in the soils is present as iron oxides. Copper in plants can both interfere with the iron metabolism and lead to iron deficiency. An organic compound has the ability of chelating compounds. This is effective in retaining certain minor elements. The chelating ability of organic matter may unite micronutrient cat ions such as iron, zinc, copper and manganese to improve their mobility (Dierberger et al, 1982).

LITERATURE CITED

ANONYMOUS, 2001. *Heavy Metals in the Environment.* http://jeq. scijournals-org/cgi/ content/full/30/3/878

ANONYMOUS. 1996. *Vetiver grass.* Chaipattana Network Webmaster. http://www.chaipat.or.th/vetiver_e.html.

BRADY, N. C. and R. R. WEIL. 2002. *organic matter reaction: The nature **and** properties of soils.* 13th ed. Upper Saddle River, New Jersey, USA: Pearson Education, Inc. pp. 375, 401-402, 521.

BUREAU OF SOILS. 1978. *Soils and land evaluation projects of the Philippines.* Department of Agriculture. Unpublished report.

CAREW, P. and J. WORK. 1957. *Vegetable Production and marketing.* New York: John Wiley and Sons, Inc. P. 449.

DALADAG, R. A. 1987. *Physical properties of soil with mine product deposits.* Unpublished undergraduate thesis. MSAC. La Trinidad, Benguet. pp. 3-4, 15-18.

DE GUZMAN, A. M. 1986. *A study of some physical, chemical, and biological properties of mine tailings in Bagnio and Benguet.* Unpublished undergraduate thesis. MSAC. La Trinidad, Benguet. pp. 3-6.

DIMERBERGER, B., A. JONES and B. SORENSEN. 1982. *Soil and Water Resources.* http://hort.unl. edu/ffa/sol&wat.htm.

DONAHUE, R. L. 1997. *An Introduction to soils and plant growth.* Englewood Cliffs New Jersey: Prentice-Hall, Inc. pp. 59-61.

ELEGADO, T. S. 1981. *Performance of tomato and soils amended with mine tailings and chicken dung.* Unpublished undergraduate thesis. MSAC. La Trinidad, Benguet. Pp. 10-13.

HORE - LACEY, I. M. 1978. *Mining and the environment.* Australia: Australian Mining Industry Council. Pp. 37-42.

HUE, N. V. 1991. *Effects of Organic Acids/An ions on P Absorption and Phyto availability in Soils with Different Mineralogies.* Soil Sci. 152:463-471

HUE, N. V. 1995. Sewage Sludge. In J. E. RECHCIGL (ed). Soil Ammendment and Environmental Quality. Boca Raton, Fl: Lewis Publication.

KELLY, W. C. and H. C. THOMPSON. 1979. *Vegetable crops.* 5th ed. New York: McGraw-Hills Book Company, Inc. Pp. 140-143.

JONES, J. 2003. *Agronomic Handbook: Management of crops, soil, and their fertility.* CRC Press LLC, USA. www.ibiblio.org/ecolandtech/agriculture/forums/ sustainable-agriculture2/msg02555.html

LARDIZABAL, T. S. 1981. *The performance of sugar beets in the soil amended with mine tailings.* Unpublished undergraduate thesis. MSAC.

LAUREAN, C. 1987. *Comparative study of different sources to organic and inorganic fertilizers.* Graduate thesis. BSU. La Trinidad, Benguet.

LICUDINE, D. L. 1987. *Some physico-chemical properties of clay-loam soil with chicken dung.* Unpublished thesis. BSU. L.T.B. pp. 7-8.

LIRIO, L. G. and B. MERCADO. 1980. *Primary investigation on the vegetation of mine tailings dumps. The nature of tailings materials and amendment of its nutrient status.* Published masteral thesis. UPLB. pp. 4-5.

MAY, J. T. 1980. *Forest Nursery,* http://www.forestry.aubum.edu/smmc/class/mhandbook/chi .htmL

PANDOSEN, E. S. 1996. *Growth and Performance of different crops in various ratios of soil and mine tailings.* Unpublished undergraduate thesis. Benguet State University. La Trinidad, Benguet. pp. 3-5.

PHILEX MINING COMPANY. *1935. Philex Mining Company.* Brochure.

SCHOLEY, G. 1978. *Rice and root crop demonstration project.* Black Mountain, Inc. Annual Report.

USDA, 1996. U.S. Department of Agriculture, Washington, D.C. http://216.239.63.104/search?q=cache:EvxJleaMnnQJ:soils.usda.gov/sqi/files/sq_fou_l.pdf+effects+of+orgamc+matter+to+phosphorus+content+of+the+soil&hl=en

WALKER, S.C. 1987. Reclaiming Mining's heritage. Unpublished report. International Mining. Cii house, 31 Theobald Road, London Eel. October 1987. pp. 21-26.

WONG J. W. and L. X. ZHOU, (2001). *Effect of Dissolved Organic Matter from Sludge and Sludge Compost on Soil Coion.* Journal of Environmental Quality *30:878-883*

Factor Analysis of Factors Influencing Adoption of Crop Insurance by Wheat Farmers in Khuzestan Province, Iran

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INTRODUCTION

Agricultural activities are usually carried out with different risks such as natural disasters. To reduce financial loss, crop insurance is one of the most important mechanisms employed by farmers. This is an innovation which is relatively new to some farmers in the rural areas especially in the third world. There are different factors influencing adoption of crop insurance. The steps, and mechanics of the adoption process have been explained in different studies (Rogers, 1995). These studies view innovation as a key issue related to technology changes and they have been focused on adoption rate and its level (Rogers, 1995).

Various studies have explained the adoption process in the form of systematic models. The diffusion model was the most widely used pattern for adoption of innovations (Rogers, 1983). Based on this model, innovative farmers adopt the new ideas and these ideas are transferred to other farmers in time. The focus of this model is in relationship between awareness and adoption. Awareness is perceived as an essential condition for adoption of innovations in the diffusion model (Hooks *et al.*, 1983).

Another necessary condition for adoption is a favorable attitude toward innovation. The model says that knowledge gained through access to different information sources is posited to be an important determinant of adoption behavior (Rogers, 1995). Also, the diffusion model asserts that adopters' characteristics are important determinants of adoption process. It is hypothesized that farmers' education, age and farming experiences is related to adoption.

The diffusion model was criticized (Rogers, 1983), so that the farm structure model (economic constraint model) was offered. This model emphasizes access to resources as predictive factors of adoption (Napier *et al.*, 1984). Also, the farm structure model emphasizes profitability and economic motives for adoption of innovations. Based on this model, the socio-economic status of farmers is related to adoption behavior.

Another study provided an alternative model to identify adoption process. The multiplicity model combines the diffusion and farm structure models to explain adoption process (Nowak, 1987).

Different studies had been conducted regarding adoption of crop insurance and its determinants. Mishra (1999) revealed that increasing the value of insurance, identifying the target farmers, to provide financial resources and suitable communication with farmers are the major determinants of adoption of crop insurance. Vandenveer (2001) said that individual characteristics of farmers, their education and income from the farm are related to adoption of crop insurance.

A number of studies showed that there is positive and meaningful correlation between size of land and the value of farm with the demand for insurance (Goodwein, 1993). Smith and Baquet (1996) concluded that the adoption of crop insurance is influenced by variables like farmers' education, the level of risk, and the variation in productivity and the value of insurance. Baker (1990) emphasized the importance of the farmers' knowledge. He argued that the more knowledge the farmers have regarding crop insurance the greater the demand for crop insurance in rural areas.

Darijani and Ghorbani (1998) revealed that the adoption of insurance among farmers are related to amount of loans, amount of farm, kind of agricultural activity and level of risk. The study of Rayatpanah (1995) showed that access to communication channels, extension and education methods, and the rate of employment influence the adoption of crop insurance. Naimi-Nezamabadi (1998) indicated that attitude and knowledge regarding the insurance process, and its advantages were the major factors to adopt crop insurance. Analysis of factors affecting farmers' adoption of crop insurance was the major objective of this study.

Methodology

The respondents of the study were farmers producing irrigated wheat in Khuzestan province. Khuzestan is one of the big provinces and is situated in south-west of Iran. Khuzestan province has the most number of rivers. It has warm and humid weather. The province is divided into two: northern Khuzestan and southern Khuzestan. Respondents from northern Khuzestan were 1830 and those from southern Khuzestan were 3172, with a total of 5002 wheat producer respondents. Proportional stratified random sampling

was used to determine the number of sample population. Geographical division (*Shahrestan*) was considered in identifying the strata of this study. Based on proportion of wheat producers' population in each *Shahrestan,* the sample size was determined using the Kucran sampling formula. Table 1 shows the total population of each Sharestan and their corresponding sample sizes.

Table 1. Total population and sample sizes of each strata determined through proportional stratified random sampling.

Northern Khuzestan			Southern Khuzestan		
Shahrestan	Population	Sample size	Shahrestan	Population	Sample size
Iezeh	182	14	Behbahan	549	42
Shush	600	45	Shadegan	523	40
Shush tar	210	16	Ahvaz	626	48
Dezful	320	24	Hendijan	780	59
Andimeshk	312	24	Dashte-azadegan	282	21
Masjed soleyman	206	16	Ramhormoz	412	31
Total	1830	139	Total	3172	241

Survey was used as research method in the study. The questionnaire used for data collection, was pilot tested and examined using Chronbach Alpha test for internal consistency and reliability. The alpha parameter was 0.88. The data were collected by conducting face-to-face interview with the farmers.

FINDINGS

In terms of educational level of the sample respondents, about 24, 25, and 20 percent of them reached primary, secondary, and high school levels, respectively (Table 2). This means that almost all of the wheat producers have adequate or desirable levels of educational attainment.

Table 2. Educational level of respondents

Education level	Frequency	Percent
Literacy	68	18.5
Primary school	88	23.9
Secondary school	90	24.5
High school	72	19.6
Diploma and higher education	50	13.5
Without any response	12	-
Total	380	100

Spearman correlation coefficient was executed to determine correlation rate between independent variables and farmers' acceptance of crop insurance (Table 3). Age had a significant negative correlation with insurance acceptance. It means insurance acceptance rate is higher between younger farmers. If we assume crop insurance as an innovation, it is natural that acceptance of crop insurance will be least among older farmers. Farmers with higher level of education have better understanding as far as the crop insurance advantage is concerned. Their adoption increased with the increase of their educational level.

Table 3. Correlation coefficients between independent variables and farmers' acceptance of crop insurance

Variables	r
Age	-0.265**
Level of education	0.508**
Farmer's wheat crop area (Hectare)	0.213**
Background on wheat cultivation (Year)	-0.106
Income	0.219**
Farmers awareness of goals and advantages of crop insurance	0.598**
Consultation with other farmers	0.373**
Participation in training classes and sessions	0.888**
Frequency of contact with insurance agents	0.626**
Participation in extension lectures	0.857**
Watching films and video clips related to crop insurance	-0.012
Study of extension bulletins and journals related to crop insurance	0.079
Visiting of crop insurance company's activities	0.855**
Participation in crop insurance workshops	-0.011
Contact with agricultural extension agents	0.678**

* Significant at 0.05 level of probability

** Significant at 0.01 level of probability

Background on wheat cultivation had no correlation with insurance adoption. However, adoption rate increased with the increase of wheat crop area and farmers' income enhancement, significantly. These findings are justified by the fact that threat of unexpected factors is increased by increasing crop area and farmers expect to counter these threats through crop insurance. Besides, farmers with higher income have less difficulty to pay crop insurance charges.

Farmers' awareness of goals and advantages of crop insurance; consultation with other farmers; participation in training classes and sessions on necessity of crop insurance; frequency of contact with insurance agents; participation in crop insurance workshops; and frequency of contact with agricultural extension agent all had significant correlation with crop insurance acceptance.

Multiple regression analysis using the stepwise method was executed to determine independent variables' influence on crop insurance acceptance (Table 4). The variable "consultation with other farmers" could explain 81 percent of dependent variable changes (R^2= 0.81). This shows that consultation and communication between and among farmers is important for decision making as far as crop insurance acceptance is concerned. In fact, most farmers feel they had similar conditions, and they believed that an experience of one farmer can be generalized to apply to other farmers. Considering that the replicability of an innovation is one criterion for applicability and adoption, one farmer's experience in crop insurance will become an important input to other farmer's decision making.

Frequency of contact with insurance agents explained 15 percent of changes in the dependent variable (Table 4). It revealed the important role of insurance agents towards farmers' acceptance of crop insurance. Insurance agents in fact ranked second information source of farmers, next to "consultation with other farmers" in relation to their decision to accept or reject crop insurance. These two independent variables explained 0.96 percent of the changes in the dependent variable.

Farmers' awareness on the goals and advantages of crop insurance explained 2.3 percent of change in the dependent variable (Table 4). Awareness is important because it is the first step towards adoption of any introduced innovations.

Table 4. Results of multiple regression analysis using the stepwise method to determine independent variables' influence on crop insurance acceptance

Independent variables	B	S.E.B	Beta	R^2 adjust	R^2 change	T	Sig.
Consultation with other farmers	2.41	0.126	0.579	0.81	0.81	19.15	0.000
Frequency of contact with insurance agents	1.01	0.102	0.363	0.96	0.15	9.95	0.000
Farmers awareness of goals and advantages of crop insurance	1.30	0.207	0.189	0.983	0.023	6.30	0.000
Size of farmers' wheat crop area	-0.133	0.044	-0.71	0.987	0.004	-3.017	0.006
Dependent variable: Crop insurance acceptance							
F= 533.36 Sig: 0.000 Constant= 5.50							

Finally, size of land which each farmer allocated to wheat cultivation was the fourth factor considered to influence crop insurance acceptance (R^2=0.004). It explained 98.7 percent of the change in the dependent variable.

Factor analysis of factors related to adoption of wheat insurance

The correlation of the factors entered for factor analysis was determined using the Kaiser-Meger-Olkin (KMO) parameters. Only factors having higher than 1 Eigen values were selected. With 0.99 level of significance, a total of nine factors were extracted which explained 75.03 percent of the total variance. These factors were shown in Table 5.

Variables' considered for each factor determined through Verimax method are shown in Table 6. It should be mentioned that 24 variables after Verimax rotation were eliminated because of low factor loading (less than 1) and non significance of their correlation with other factors. The reason was that the level of these variables had overlap with more important

Table 5. Extracted factors with their specifications

Factors	Special Amount (Eigen value)	Variance Percent of S.A.	Cumulative Frequency of Variance Percent
First	7.48	22.67	22.67
Second	4.18	12.67	33.35
Third	2.74	8.31	43.67
Fourth	2.45	7.45	51.12
Fifth	2.27	6.90	58.02
Sixth	1.69	5.12	63.15
Seventh	1.53	4.65	67.8
Eighth	1.22	3.71	71.52
Ninth	1.15	3.51	75.03

variables and so the researchers decided to integrate them with the other variables.

The factors affecting crop insurance acceptance which resulted from the factor analysis have been classified into nine factors. These are presented in Table 6. They are: 1)Extension-education; 2)Economic; 3)Communication channels; 4)Motivation; 5)Opinion on leadership; 6)Facility; 7)Confidentiality; 8)Supervision; and 9)Diversity factors. These factors explained 75.03 percent of the total variance, as have already been mentioned. The extension-education factor which Eigen value was 7.48 could explain 22.67 percent of the total variance. This factor is deemed the most important factor compared with others. Its' variables include conduct of workshops and training classes, distribution of bulletins and leaflets, use of newspapers, radio and TV programs, to promote the insurance and persuade farmers, etc.

Economic factor was the second factor that could explain 12.67 percent of total variance with value of 4.18. Its' variables included size of area or land for wheat cultivation, land revenue system, income, payment for insurance contract, and discount for insurance of agricultural crops (Table 6).

The third factor was communication channels. This factor with the value of 2.74 could explain 8.31 percent of the total variance. Its' variables included awareness on advantages of having crop insurance, linkage with insurance agents, and delivery of information on the insurance to farmers. Motivation factor was considered as the fourth factor. This factor with 2.45 value could explain 7.45 percent of the total variance. Its' variables were three: on time indemnity payment, discount enjoyed by farmers who had no crop damage, and giving of presents to farmers by insurance companies.

Opinion on leadership was the fifth factor. Its value of 2.27 explained 6.9 percent of the total variance. Arrangement of group discussions on crop

Table 6. The factors and their coefficients as extracted from rotated matrix

Factors	Variables	coefficient
Extension-education factor	Conduct of training classes on advantages of crop insurance	0.857
	Distribution of training bulletins and leaflets	0.707
	Conduct of workshops	0.875
	Linkage with agricultural extension agents	0.779
	Distribution of newspapers featuring crop insurance activities	0.699
	Use of radio programs to enlighten farmers on advantages of crop insurance	0.843
	Use of TV to enlighten farmers on advantages of crop insurance	0.834
	Use of films and multimedia to promote crop insurance	0.573
Economic Factor	Size of land area devoted to wheat cultivation	0.902
	Land revenue system	0.768
	Farmers' income	0.803
	Payment for primary insurance contract	0.735
	Discount on agricultural crops insurance	0.859
Communication Channels Factor	Awareness on advantages towards of crop insurance	0.767
	Linkage of farmers with crop insurance agents	0.897
	Information delivery on crop insurance to farmers	0.819
Motivation Factor	On time payment of indemnity to farmers	0.522
	Discount for farmers who have no crop damage	0.671
	Giving of presents to farmers by insurance companies	0.603
Opinion on Leadership Factor	Arrangement of group discussions on advantages of crop insurance	0.742
	Capacity of local leaders to encourage crop insurance availment	0.877
	Capacity of local council to encourage crop insurance availment	0.515
Facility Factor	Facility toward indemnity payment	0.877
	Discount for farmers who have no crop damage	0.532
	Insurance companies' capacity to deliver prior commitments	0.712
	Ease in the processing of papers/contract for crop insurance	0.591
Confidential Factor	Satisfaction of farmers of the benefits of having crop insurance	0.940
	Insurance agents' capacity to persuade farmers to insure their crops	0.943
Supervision Factor	On time payment of indemnity to farmers	0.613
	Continuous monitoring for proper processing of insurance by inspectors	0.569
Diversity Factor	Diversification of crop insurance options	0.825

insurance advantages, and capacity of local leaders and local council to encourage farmers to have crop insurance were among the variables of this factor. The sixth factor was facility which could explain 5.12 percent of the total variance with a value of 1.69. Its' variables were ease in paying indemnity; discount consideration for farmers who were without crop damage; capacity of insurance companies to perform and deliver earlier commitments; and ease in processing the papers or contract for crop insurance.

Confidential factor was the seventh factor with a value of 1.53 which could explain 4.65 percent of the total variance. It had two variables: satisfaction of insurer farmers of the benefits of crop insurance; and insurance agents' capacity to persuade farmers to insure their crops. Supervision factor with a value of 1.22 was the eighth factor which explained 3.71 percent of the total variance. This factor consisted of two variables: on time indemnity payment to farmers; and continuous monitoring for proper processing of insurance by inspectors. Diversity was the ninth and the last factor with a value of 1.15. It explained 3.51 percent of total variance and only had one variable diversification of crop insurance options.

Conclusion and Recommendations

Agriculture is a risky undertaking with natural disasters as its most common threats. Almost 31 of 40 types of natural disasters recognized by the world occur in Iran. In fact, Iran ranked tenth among countries in the world oftenly visited by natural disasters. Insurance is one of the common strategies used to counter threats in agricultural production although there are several factors that farmers cannot control because they are unpredictable. Crop Insurance in Iran has an important role in agricultural production. Encouragement of farmers to insure their crops by extension agents could be an appropriate strategy to counter agricultural risks.

Analysis of factors related to adoption of crop insurance by wheat farmers was the main objective of this study. Findings revealed that the farmers with higher rate of crop insurance acceptance were younger with higher level of literacy, had bigger crop area, had more income, were more aware on the goals and advantages of having crop insurance, had frequent consultation with other farmers and had better participation in training classes and sessions. Also, the frequency of their contact with agricultural extension and insurance agents was higher, and had more participation in extension lectures and activities organized by crop insurance company.

Multiple regression analysis revealed that four independent variables could explain about 99 percent of farmers, level of acceptance of crop insurance. These include consultation with other farmers, frequency of contact with insurance agents, farmers' awareness of goals and advantages of crop insurance, and farmer's crop area devoted to wheat production.

The 31 variables affecting crop insurance acceptance were classified into nine factors and analyzed using the factor analysis technique. The nine general classifications of factors helped authors to achieve higher theoretical level in relation to the factors which influence on crop insurance acceptance. Consequently, extension-education, economic factor, communication channels, opinion on leadership, facility, confidentiality, supervision, and diversity factors all influence the farmers' crop insurance acceptance. They could explain about 75 percent of the total variance. Based on the findings, the following are recommended:

In order to accelerate adoption of crop insurance, identifying the first adopters from among the farmers is very important. The first adopters can share experiences; lessons learned and best practices to other farmers. This is considering the main finding of the study that farmers' consultation with each other plays an important role in their decision-making especially on the adoption of crop insurance. Furthermore, extension educational programs towards crop insurance should be strengthened. This again is based on the finding that the former do influence acceptance of crop insurance by farmers through their motivation and supervision, among others.

Reference

Baker, E.j. (1990) Demand for area crop insurance among litchi producers in northern Vietnam, agricultural economics 26: 173-184

Bequet, A.E. & skees, j.(1995).group risk plan insurance: An alternative management Tool for farmers, choices 1: 25-28

Darijani&Ghorbani (1998) the impact of crop insurance on wheat farmer risk Reduction press institute of Iranian economic investigation and planning

Goodvin, B.K. (1993) An empirical analysis of the demand for multiple peril crop insurance. American journal of agricultural economics 75: 425-434

Rogers, E.M. (1983). Diffusion of Innovations (third edition). New York: The Free press.

Rogers, E.M. (1995). Diffusion of Innovations (fourth edition). New York: The Free press.

Hooks, G.M., Napier, T.L. and Garter, M.V. (1983). Correlates of adoption behaviors: The case of farm technologies. *Rural Sociology*, 48, 308-323.

Mishra (1999) insurance as risk management tool for European agricultural, pergamon press, oxford

Naimie-nezamabadi (1998) Factors influencing on development of crop insurance master thesis department of management Tehran University

Napier, T.L., Thraen, A.G. and Goe, W.R. (1984). Factors affecting adoption of conventional and conservation tillage practices in Ohio. *Journal of Soil and Water Conservation*, 39, 205-209.

Nowark, P.J. (1987). The adoption of agricultural Conservation technologies: Economic and diffusion explanation. *Rural Sociology*, 52, 208-220.

Vandeveer, M.L. (2001) Demand for area crop insurance demand for area crop insurance among litchi producers in northern Vietnam, agricultural economics 26; 173-184