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Environmental Friendly Agricultural Practice In The Southwestern Coastal Zone Of Bangladesh To Adapt With Climate Change

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Abstract:
In the coastal area, 28 % people of total population lives where 16 % of total rice of Bangladesh is being produced. Although arable land is decreasing, modern technologies help to increase food production. However, impacts of inappropriate application of chemical fertilizer, pesticides and climate change constrain the agricultural progress. The objective of the current study is to find out suitable existing environmental friendly agricultural practice that can adapt with climate changing condition. Dacope and Dumuria upazilas of Khulna district were the study area which situate at the southwestern coastal region of Bangladesh. Three types of available agricultural practices had been identified which were rice cultivation, combined rice and fish culture, and vegetable cultivation. Ten Rice Farmers (RF), ten combined Rice and Fish Farmers (RFF), and five Vegetable Farmers (VF) had been interviewed. VF use comparatively low amount of chemical fertilizer than other farmers. Farmers do not use organic fertilizer due to scarcity of enough manure, requirement of large volume, and additional transportation and labor cost. No farmers follow satisfactory safe pesticide management. Farmers are polluted by pesticide through absorption, inhalation and ingestion. Perching method is the only method of integrated pesticide management (IPM) that is applying in the field. Other IPM methods are not successfully applied in the field because lack of group wise initiative, available chemicals and apparatus, and requirement of additional cost. RFF get extra biological control from fish than other two types agricultural practices. Low visible salt effect significantly increases the soil quality of the RFF's land which has the best quality of soil than other farmers' lands. Moreover, rice and fish culture has additional advantage to reserve rainwater that can be used for irrigation at water scarcity condition. Rice and fish culture is the most environmental friendly available practice in the southwestern coastal region that has potentiality to adapt with climate changing scenarios.
Keywords: *Adaptation; Bangladesh; Climate change; Environment; IPM; Pesticide; Soil health card.*

1.Introduction

Bangladesh has 147,570 km^2 land area that includes 710 km coastal line along with the Bay of Bengal. Population density in the coastal zone is about 743 people per square kilometer where 28 % of total population of the country lives (BBS, 2003). Total coastal zone has 47,201 km^2 (M. S. Islam, Razzaque, Rahman, & Karim, 2004) where cultivable land covers 59 % in which 16 % of total rice of Bangladesh is being produced (Ahmed, 2011). About 17 % of coastal zone area covers fisheries, including shrimp culture, and wetlands (R. Islam, 2006). In Bangladesh, about 220 ha of arable land is being lost daily (M. S. Islam, et al., 2004), however, food demand is increasing almost exponentially. To ensure food security of the country it is necessary to ensure maximum utilization of agricultural land. Although, agricultural land area is reducing, crop production significantly increases due to implication of modern agricultural technologies such as adoption of high yielding and hybrid crop varieties, mechanical tillage, improvement in irrigation facility, and timely supply of chemical fertilizer and pesticide.

Climate change may constrain the agricultural progress in Bangladesh. The impact of climate change on the existing crop species and crop patterns are expected most. Due to temperature and humidity changes, crop production may reduce. New varieties need to be developed or the cropping patterns should be changed to adapt with the changing environment. To ensure sustainable development in agriculture and environment, it is necessary to maintain good land usage along with optimum dose of chemical fertilizer and pesticide. The farmers use chemical fertilizers as a supplemental source of nutrients but they do not apply in balanced proportion (BARC, 2005). In Bangladesh, fertilizer management practice is very poor where most of the farmers use only urea fertilizer, which is often above recommended dose (M. M. Islam, et al., 2011). Excess usage of urea fertilizer and pesticide are very common practice among farmers that can lead to serious degradation of soil quality, and contaminate surface and ground water resources. Over dose of pesticide creates resistivity among insects that causes ineffectiveness of pesticide, which is one of the most common problems in pest management. Moreover, exposure of pesticides is 0.02 mg/kg/day in Bangladesh which is much higher than the acceptable level (0.005 mg/kg/day) (M. H. Rahman & Alam, 1997).

Low organic matter in soil is another important problem for Bangladesh. Organic matter is known as 'storehouse of plant nutrients' and ‘life force of a soil'. A good soil should have at least 2.5 % organic matter, but in Bangladesh most of the soil has less than 1.5 %, and some soil possess even less than 1 % organic matter (BARC, 2005). This makes

Bangladesh as one of the lowest soil organic matter rich countries in the world. Moreover, coastal region is the area where most dynamic and critical environment exists. Almost every year, the area suffers from natural hazards such as cyclone, storm surge and tidal flooding that cause inland sea water intrusion through surface and subsurface. During 25 May 2009, a catastrophic cyclone AILA of category 1 struck the southwester coastal region of Bangladesh. The maximum storm surge height varies between 1.40 m to 2.95 m (M. M. Rahman, Paul, & Hoque, 2011). The saline water rushed into the agricultural field and increased the soil salinity. About 79,003 acre of crop land was damaged fully and 249,801 acre partially due to soil salinization caused by the cyclone AILA (DMB, 2009).

The diversified natural and anthropogenic activities make the coastal region a challenging area for agricultural practices. The objective of the current study is to find out suitable existing agricultural practice that can adapt with climate changing condition and at the same time which will also be environmental friendly.

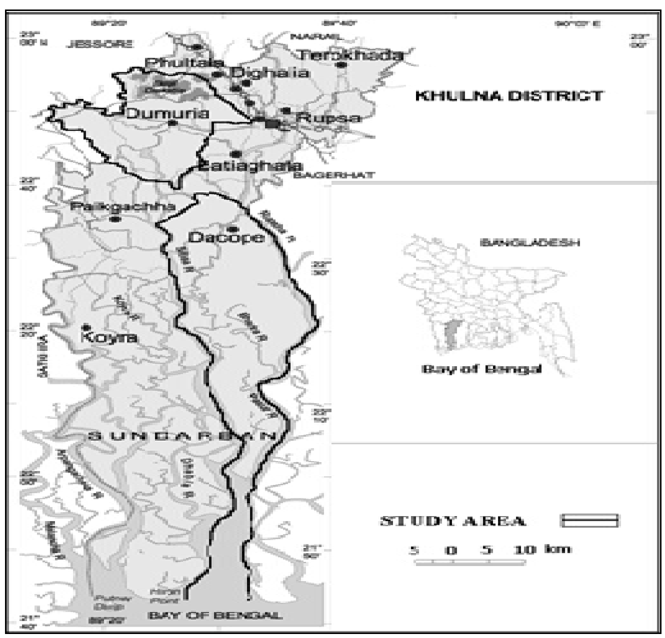

Figure 1:Location Of Dacope And Dumuria Upazilas Of Khulna District That Are Situated In The Southwestern Coastal Zone Of Bangladesh

2.Methodology

2.1.Study Area

The study area was Dacope and Dumuria upazilas of Khulna district which is situated at the southwestern zone of Bangladesh (figure 1). Dacope is located adjacent to the mangrove forest, the Sundarbans, and the Bay of Bengal. Dumuria is positioned just north of Dacope. The salty river channels of the area are regularly inundated by high and low tides from the Bay of Bengal.

2.2.Data Collection

A structured questionnaire was developed to collect information on four criteria – (a) the fertilizer application, (b) pesticide application, (c) integrated pest management (IPM) and (d) farmland's soil quality. First three criteria provide information on the existing agricultural practices and last criterion reveals a combined effect of other three. Again, first three criteria help to find out more environmental friendly agricultural option and fourth criterion verifies whether that agricultural option can maintain consistent yield in climate changing scenarios regarding on soil quality.Key Informant Interview (KII) was used to collect information from the farming communities. Total 25 farmers were selected purposively for KII through accidental sampling technique. For analysis, three farming groups among 25 farmers, which are Rice Farmers (sample size, n=10), Rice and Fish Farmers (n=10), and Vegetable Farmers (n=05), denoted as RF, RFF and VF, respectively had been chosen. Rice and Fish Farmers cultivate rice and fish simultaneously on the same land in the wet season where pond is situated adjacent of the rice field and the rice field is surrounded by strong and about a meter high earthen dyke to keep the fish within the rice farm. Similarly for convenient in analysis, land of the study area had been divided into three groups as Rice Land, Rice and Fish Land, and Vegetable Land denoted as RFL, RFFL and VFL, respectively.

2.3.Soil Health Card

Soil health card is a measuring scale of soil quality. It largely depends on farmer's perception. The most important advantage of using this card is that – it does not require any analytical method to determine soil quality. A minimum set of indicators is required to obtain farmer's view on soil health of the agricultural fields. For the study, four indicators had been selected to assess soil quality based on their greater influence on soil property (table 1). In this card, total scores 10 to 12 indicates Good, 7 to 9 indicates Medium and 4 to 6 indicates Poor quality soil. The individual farmer determined the score during the interview.

Indicators	Ranking Criteria			Score		
	Low (L)	Medium (M)	High (H)	L	M	H
Number of Earthworm	0-1 earthworm in a shovelful of top soil of about 30 cm deep and no hole in soil profile.	2-10 worms in shovelful soil and a few holes in soil profile.	> 10 worms in top soil and lot of holes in tilled clods.	1	2	3
Soil Color	Topsoil color similar to subsoil color.	Topsoil color slightly `darker than subsoil color.	Topsoil darker than subsoil.	1	2	3
Roots/residues	No visible residues or roots	Some residues, few roots	Noticeable roots and residues	1	2	3
Salts	Visible symptoms of salt/alkali, dead plants	Stunted growth of plants, signs of leaf burn from salts	No visible symptoms of salt, alkali or plant damage	1	2	3
			Sub-total			
			Total			

Table 1: Soil Health Card To Assess Soil Quality

3.Results And Discussion

3.1.Fertilizer Usage

In the study area, most of the farmers cultivate high yielding and hybrid varieties of crops. Farmers received training from the promoters on cultivation procedure including fertilizer application instruction. RF and RFF apply mainly chemical fertilizers to grow rice and non-rice crops. However, it is found that only 20 % farmers of both rice and non-rice cultivars use limited amount of cow dung as organic fertilizer. Another 4 % farmers have prepared compost made of household kitchen waste, which is not sufficient for sustaining production at satisfying amount. More than 85 % farmers do not take any initiative to produce organic fertilizer. Farmers do not widely use organic fertilizer because of three main constrains. First one is the scarcity of draught cattle due to shortage of fodder and sweet drinking water. Cattle population in the coastal area has been reduced by about 73

% within 14 years (A. M. S. Ali, 2005). An important reason for reducing draught animal is the agricultural mechanization. All rice farmers in the study area are using power tiller for field preparation. Decreasing of draught animals brings significant reduction in homemade organic fertilizer because the manure from the domestic bulls and cows is the prime ingredient of organic fertilizer. Second important reason is the requirement of huge quantity of organic fertilizer to satisfy the nutrient needs of the crops. Organic fertilizer contains comparatively less nitrogen and other macronutrients than same volume of chemical fertilizer. Due to the crop intensification, huge amount of organic fertilizer is need. Finally, another problem is the additional transportation and labor cost for such large volume of organic fertilizer. Although there are some limitations for organic fertilizer application in the crop field, the best result in production can be achieved when chemical and organic fertilizers are applied together for crop production (M. E. Ali, Islam, & Jahiruddin, 2009). The VF is using less chemical fertilizer comparing with RF and is applying both organic and chemical fertilization to produce vegetables. VF dumps the kitchen waste and animal manure in the vegetable land which convert to organic fertilizer.

3.2.Pesticide Usage

During the field investigation, several names of pesticides and fungicide used by the farmers have been collected (table 2). According to the WHO Recommended Classification of Pesticides by Hazard the used pesticides and fungicide are highly to moderately hazardous (WHO, 2009). Moreover, dioxathion is obsolete as pesticide, which is still using to prohibit pests.

Common name		**WHO (2009) category**	**Type**
Pesticide			
Carbofuran		Highly hazardous	Carbamate
Dioxathion		Obsolete as pesticide, not classified	Organophosphorus compound
Diazinon		Moderately hazardous	Organophosphorus compound
DDVP		Highly hazardous	Organophosphorus compound
Cartap		Moderately hazardous	Carbamate
Fungicide			
Propiconazole		Moderately hazardous	Organophosphorus compound

Table 2:Categorization Of Used Pesticide And Fungicide

To control or reduce pest invasion or disease, pesticide and fungicide are needed to apply in the farmland with a specific guideline which should be strictly followed; otherwise effectiveness of the doses will be reduced. RF applies pesticides and fungicides when they think that pest is invading or going to invade the crop. Excessive use of pesticide can make the pest resistant to it (Landis, et al., 2002). All farmers ensure high resistivity of insects to pesticide. Moreover, VF usually sprays pesticide in the vegetable garden twice in a month. They consume the vegetables within fifteen days of pesticide application that may cause pesticide pollution in the body through ingestion. Because, the residual effect of the applied pesticide may remain for at least two weeks.

Pesticide is not handled according to safety rules and regulations. About 60 % farmers receive training on handling of pesticide from local Department of Agriculture Extension officials of the Government of Bangladesh. However, the farmers only follow partial safely handling procedure of pesticide. Pesticides should be applied at the wind flow direction. No respondents follow it and do not have consciousness about it. The farmers intend to apply pesticides at regular intervals from vegetative stage of crops up to harvesting. Even it is found that 10 % farmers of RF apply pesticides after every ten days without considering the intensity and magnitude of pest invasion. No personal safety equipment or measure is taken during preparation, application and washing of pesticide sprayer. As a result, farmers are subjected to direct chemical exposure. All the farmers prepare the pesticide solution and wash the sprayer and other stuffs with bear hands. Furthermore, defective sprayer is using to apply pesticides. By the leakages of the sprayer, the farmers directly come to dermal contact with the pesticide solution that absorbs through skin. In winter season, temperature of soil is less that lead to volatilization of pesticides. There is a risk of upward mass transfer of organophosphate from dry soil (M. H. Rahman & Alam, 1997). Therefore, volatile chemical may affect farmer's body system through inhalation since no musk is used. Emphasizing on handling method, overall pollution process of pesticide in the study area can be illustrated as in figure 2. Farmers preserve excess unused pesticide in the home from where the residents can be affected by the pesticide pollution through inhalation due to volatile nature of pesticide and through skin absorption during handling. Pesticide pollution may have short-term and/or long-term effects on body function that may lead to reduction of disease resistivity, damage of organs, malfunction of nerve system, stillbirth, birth defect, cancer etc. In integrated rice cultivation and fish culture activity, the invasion of pest is less than traditional rice field especially during the rainy season when rice field is inundated by seasonal flood. At that time, the farmers usually take special care for pesticide application and use the pesticide in more controlled dose, so that it will bring minimum harm to fishes. One good practice is found to be followed by all farmers. Pesticides should not be applied under the bright sun. Hundred percent farmers know the right hour of the day for pesticide application and follow it.

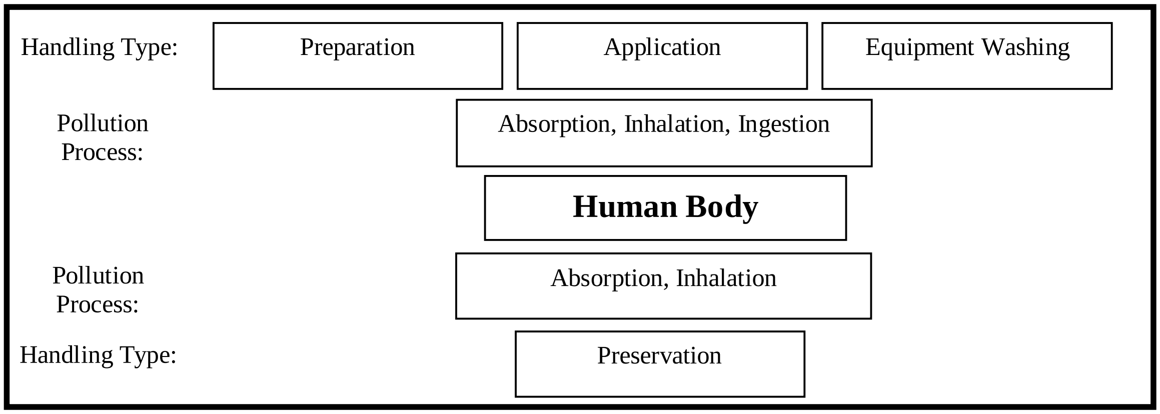

Figure 2: Pollution Process Of Pesticide During Handling

3.3.Application Of Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM program use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to the people and the environment (EPA, 2012). During the green revolution, pesticide becomes an essential input to increase crop production by neglecting other pest control means. In Bangladesh, from 1984 to 2010, pesticide consumption increases for about 92 % (figure 3).

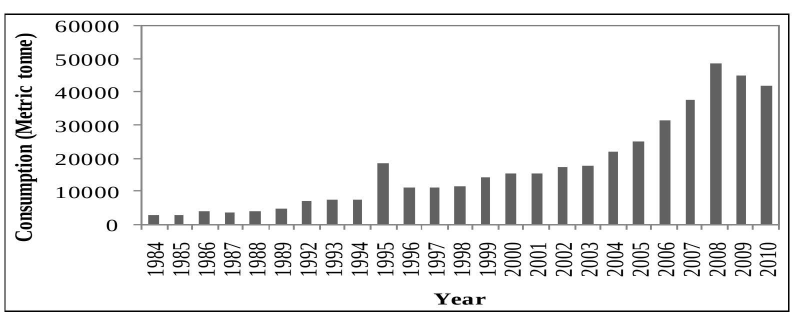

Figure 3:Pesticide Consumption In Bangladesh (PAB, 2010) And (M. H. Rahman & Alam, 1997).

IPM is not a single pest control method but, rather, a series of pest management evaluations, decisions and controls (EPA, 2012). In the study area, only perching method is using to facilitate birds to sit and eat insects as a preventive approach of IPM. However, other pest controlling mechanisms are not applying in the field. Farmers do not have much interest to comply IPM in their fields. About 56 % of all farmers reported that the main constrain is the lack of group wise initiative. To be effective, IPM must be taken as group effort. Other reported constrains are lack of available chemicals (20 %) e.g. pheromone for the pheromone trap, lack of required apparatus (12 %) e.g., hand net, requirement of additional expenses (8 %) e.g. cost for light trap and general notion on laborious cumbersome technique of IPM (4 %). RFF experiences lower pesticide invasion during the rainy season when the rice field is flooded and fish can freely move from pond to rice field. This biological control is a part of IPM that provides RFF additional support besides perching method to grow rice in lower pest environment comparing with other two farming lands.

3.4.Soil Quality

According to the Soil Health Card, among three farmer groups, RFF's land has the highest quality of soil followed by VF's and RF's lands. The average scores for RFFL, VFL and RFL are 9, 7 and 6, respectively. Criteria wise individual scores are shown in figure 4. Based on this score, the soil quality of RFL is determined as Poor, and other two farmer groups practice agricultural activities on Medium quality soil.

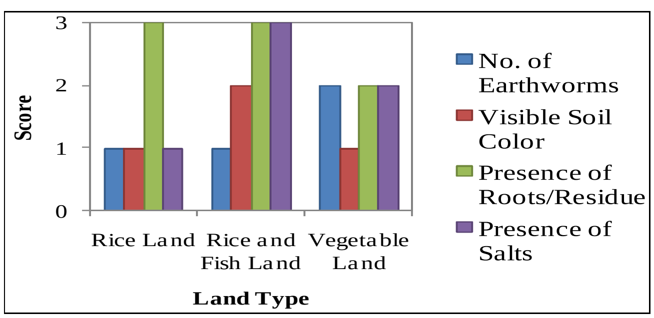

Figure 4: Individual Score Of Three Land Types According To Soil Health Card

The reasons of low soil quality in RFL are low or absence of earthworm, no color difference between topsoil and subsoil, and presence of high salts. The score is boost due to the presence of high roots and residues of plants in the soil. Low or absence of earthworm may be occurred due to high and/or over dose of synthetic ingredient as well as high salt content in the soil. Naturally, the coastal area soil is saline in nature due to saline water intrusion through the shallow aquifer. Deep aquifer system is also saline due to the paleo-brackish water entrapment in the aquifer (M. A. T. M. T. Rahman, Majumder, Rahman, & Halim, 2011). High tide also brings saline water into the land through river and canal systems. During dry season, farmers use this saline water for irrigation purpose due to lack of fresh water to irrigate crops. As a result, the top soil salinity increases in the dry season. Besides, the devastating category-1 cyclone AILA hits the coastal area of Bangladesh in 25 May 2009 that causes further salinization. In case of RFFL, the number of earthworm is low or absence that reduces the overall soil quality. The visible effect of salt is minimum in rice-fish system that significantly increases the soil quality compare to other two types of land. Because the rice field of this type comes to contact with only rainwater that washes excess salt from the soil. In the rainy season, total land is inundated by rainwater and in the dry season, required irrigation water is supplied from the adjacent pond that reserves rainwater. With erratic rainfall pattern for climate changing condition, the pond water can use as irrigation water when it is required. The color difference between top and subsoil is also pronounced due to comparatively high organic matter content in rice and fish land. Fish residues, during the rainy season, add in the rice field that significantly increases the organic matter content in the soil. Additionally, low salt content and high amount of plant roots or residues in RFFL make the best quality soil among all types of land. On the other hand, in the VFL, the amount of plant roots and residues is the lowest and the visible soil salinity effect is intermediate between two types of land. However, this land has highest number of earthworm in soil (figure 4) that may indicate low foreign chemicals (pesticide and chemical fertilizer) and salt concentrations in soil, which create a favorable living condition for earthworm.

4.Conclusion

Fertilizer and pest control management is better in rice and fish farmers' land. In case of IPM, fish acts as biological control in rice and fish culture that reduces pest invasion compare to rice land and vegetable land. Soil quality is also better in rice and fish farmers' land. Moreover, combined rice and fish culture has own irrigation water reservoir, which can provide support during low rainfall or drought scenarios that may occur due to climate changing condition. Therefore, combined rice and fish farming is the most environmental friendly best available agricultural practice in the southwestern zone of Bangladesh that can also has the potentiality to adapt with climate changing condition.

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