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To *Jhum* or Not to *Jhum*: Agricultural Practices in the Chittagong Hill Tracts, Bangladesh

Dr. Mahfuzul Haque[1]

Abstract

This article is an attempt to examine the present situations of Jhum cultivation in the ChittagongHill Tracts (CHT), Bangladesh against the backdrop of this agricultural system being practiced by millions of farmers elsewhere in the world. Despite century-long anti-Jhum policies, plans, development projects and a concerted vilified campaign, Jhum continues unabated in Bangladesh and in the neighbouring countries of India, Myanmar, Bhutan, Nepal, Laos, Cambodia and in Africa and Latin America. Does it mean Jhum works? How a number of development projects, plans and policies undertaken by successive governments in Bangladesh have created an adverse situation for Jhum cultivation has been described in greater details. Present situation of the Jhumiya families and their tragic stories for survival deserve special attention. At this point, when the Jhumiyas themselves were at a loss and confused, ICIMOD study came to the rescue. Innovative and indigenous practices of Jhumiya farmers in many other countries of the world were reflected in "Shillong Declaration" adopted in 2004. The article concludes that there are many challenges ahead and the greatest challenge would be how to change the mindset created by century-long campaign against this farming system being practiced by some ethnic minority people on the fringe.

Introduction

Shifting cultivation or Jhum is common across lower and medium altitudinal ranges of the eastern Himalayas. There are an estimated 10 million hectares in South Asia under this form of agriculture. Across Asia, more than 400 million people are dependent on tropical forests and a majority of them practice shifting cultivation (Kerkhoff, and Sharma, 2006). Majority of them belong to indigenous ethnic minority groups and they subsist on variations of forest farming supplemented by hunting and gathering activities. Shifting cultivators remained on the fringes of the society-geographically, socially, politically and economically-and are among the poorest of the poor. Despite intensive and lengthy government efforts throughout the eastern Himalayan region to control shifting cultivation, the practice remains entrenched over large areas. Many experimental policies and projects taken so far could not frustrate farmers' innovations and shifting cultivation continued unabated.

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Shifting cultivation is known under different names in the different countries of South Asia. In Bangladesh and North East India it is called "*jhum*", which literally means shifting; in Myanmar it is "*taungya*" or hill cropped land; in Nepal "*khoriya*" and "*basme*", which refer to the fallow phases. In Bhutan, "*tseri*" refers to shifting cultivation with forest fallows practiced at lower elevations, while "*pangzhing*" is a similar practice at elevations close to the tree line where fallows are mainly grass and shrub (Kerkhoff, and Sharma, 2006). In India, it is practiced in Tripura, Mizoram, Nagaland, Arunachal, Madhya Pradesh, Urissa and Southern India.

Besides, the South Asian countries, shifting cultivation is also present in many other tropical countries of Laos, Cambodia, Thailand, Philippines, Indonesia and many countries of Africa and Latin America. In English, it is known as shifting cultivation, slash-and-burn, extensive agriculture, swidden agriculture, bush-fallow agriculture, forest farming, rotational agro-forestry etc. (Tripura *et al.*, 2003). In this article, for convenience, the word "shifting cultivation" would be used as English translation of the word *Jhum*.

Shifting cultivation and pastoralism, both highly successful economic systems have proven particularly vulnerable to increased population pressures and outside efforts to raise productivity beyond its natural limits (Bodley, 2008).There are a number of allegations against *Jhum* cultivation and that, it is a "primitive" form of agricultural practice; most unprofitable; destructive to environment by causing soil erosion; loss of topsoil; loss of soil fertility; and deforestation (Tripura, *et al.*, 2003). Due to century-long concerted campaign against *Jhum* cultivation and shortening of *Jhum* cycle due to faulty development policies and projects, even the *Jhumiyas* lost confidence on this form of cultivation and started losing interest on this form of cultivation. There had been a tremendous pressure by the policy makers, development practitioners, foresters and extension workers to look for the alternative to *Jhum* cultivation.

Jhum cultivation is a kind of community agriculture (Gain, 2013). The whole family or community might get engaged in it that requires hard labour and constant care. It has also a great influence on the culture of the indigenous peoples. *Jhum* happened to be a way of life for the *Jhumiyas*, it was a self-sustaining economy, from where a *Jhumiya* family used to get all their basic needs, starting from food, clothing, medicine to shelter. They used to grow enough food for themselves with an annual surplus. All their songs and dances, dreams and aspirations revolve round the *Jhum* fields. They have developed a symbiotic relationship with *Jhum*. They are the sons and daughters of the *Jhum*. Without *Jhum*, their lives are meaningless. They tend to be independent, self-sufficient peoples and their entire cultures are often neatly integrated with their agricultural cycles ((Bodley, 2008). Against this backdrop, some agricultural scientists, academia, sociologists and farmers initiated a process of re-examining the whole issue starting from its historical background of cultivation practices and its continuation in so many countries of the world today against many odds. Perhaps, the indigenous knowledge and innovative practices being followed by these new-generation farmers would bring a paradigm shift in already beleaguered *Jhum* cultivation.

Bangladesh Scenario

Jhum is a dominant form of agricultural land-use in the hilly region of the Chittagong Hill Tracts (CHT) of Bangladesh. Eleven minority ethnic groups of the hills of Chittagong practice this form of agriculture known by various names: *Hugh* (Tripura); *Yaa* (Marma); *WaahLup* (Mro); *Laotuya* (Bawm); and *Jhum* (Chakma and Tanchangya). Commonly known as *Jhum*, and the farmers as *Jhumiyas*, this form of shifting cultivation has been in practice for generations. The majority of Mros (86.4%) and Tripuras (54.8%) and a large number of Marmas (42.3%) were involved in *jhuming* practices, while only 22.7% of Chakma farmers practice *jhum* cultivation (Rafi, 2001). Approximately, 41,000 ha of land of this region (14% of total cropped area) is used for shifting cultivation every year and about 73,000 families are engaged in this traditional form of agriculture (Rasul, 2009).

Jhum is carried out predominantly on the steep slopes of the high hills. *Jhum* cultivation is characterized by a short "cultivation phase" of a few years followed by a relatively longer "forestry phase" usually referred to as the "fallow phase". *Jhum* involves a large number of activities including selection of sites, cutting of bush, trees, shrubs and creepers, burning, field preparation, sowing, weeding, guarding, harvesting, carrying and storing. *Jhum* activities cover round the year. This is almost a self-reliant production system as they produce almost everything they need. They cultivate crops, grow fruits and trees, raise livestock and catch fish. In addition, they build their own houses, make their own looms, weave their own clothes, make baskets to carry and conserve goods. Rice is the staple food in the region. Along with rice, a large number of legumes, vegetables, spices, tubers, and oilseeds are also grown in the same plot. They also grow cotton with food crops. Most of the crops are grown mainly for household consumption and to sell the surplus. Cotton is mainly grown for sale. Sesame and chili are grown for selling purpose.

After clearing and burning of bushes in March, sowing and planting start with the first rain of monsoon in April. Farmers mix all seeds proportionately including rice, maize, sesame, vegetables and cotton and sow in the same hole. Weeding is done three times in a season. Guarding of *Jhum* field from wild animals- marauding wild elephants and rats, particularly at the stage of maturity of crops is important. Harvesting continues for three to four months in phases. The first harvest starts in August with maize, followed by rice in October and cotton and sesame in November/December period. Vegetables are harvested between these periods. A *Jhum* calendar in CHT describes that site selection is done in January; slashing in February and March; burning and land preparation in April; seedling, broadcasting, dibbling in May; weeding in June-August; first harvesting of maize and vegetables in September; rice in October; and cotton, turmeric, ginger, arum, cassava, chilli and bringal in November-December (Mohsin, 2002; Rasul, 2009; and Khisa and Khisa, 2009).

Although, there is no privately owned land, there is however, a kind of unwritten law related to land claims for *Jhum*. It is *de facto* rights of the *Jhumiyas*, who have been cultivating the hilly

lands for generations. On the other hand, the government exercises its *dejure* rights claiming all lands belong to the state. Forest Department often declares an area as the forest land though government gazettes notification. This way, land availability for *Jhuming* gets bleaker and as a result pressure increases on the meager natural resources.

Land Characteristics of the CHT

The CHT, comprising of the three hill districts of Khagrachhari, Rangamati and Bandarban, is geographically an isolated region of Bangladesh. Although, it constitutes 10 per cent of the total area of the country, the area is full of hills, ravines and cliffs covered with dense vegetation (trees, bush, creeper and jungle etc) and in sharp contrast with the rest of the country, which is mainly a floodplain. The area comprises of seven main valleys formed by the *Feni, Karnafuli, Chengi, Kassalong, Sangu* and *Matamuhuri* rivers. The valleys are covered with dense bamboo breaks, tall trees and creeper jungles (Haque, 2008). Main features of the vegetation are tropical evergreen or semi-evergreen rainforests dominated by tall trees. Most of the CHT slopes are very poor and have severe limitations for plough cultivation. Steep slopes, heavy monsoon rainfall, shallow soil depth, low soil fertility and droughts are the features of this landmass.

According to the soil and land use survey by a Canadian company (Forestall Survey, 1966), the soil has been classified into seven categories. The most important ones are clay loam, sandy loam and silty clays. The most extensive is silty clay loam, which covers 67 per cent of the total area. Only 3.1% is suitable for arable agriculture and categorized as class A and 2.7% is suitable for terraced agriculture or horticulture and categorized as class B. About 89% of land categorized as C and D is suitable for tree cropping and forestry only (Haque, 1995; Tripura and Harun, 2003; and Rasul, 2009). The area experiences a complete tropical monsoon climate with hot wet summer and dry cool winter seasons. In such an isolated hilly and difficult terrain with poor soil conditions and hostile climate, the local indigenous community has been practicing *Jhum* cultivation for ages.

Anti- *Jhum* Campaign

There are some common allegations against *jhum* cultivation that due to application of "slash and burn" method, it causes loss of top soil, loss of soil fertility, killing of friendly insects, land erosion, deforestation and a telling effect on the environment. It is alleged that *jhum* farming is haphazardly done and due to decrease of fallowing period (from 10 to 3/4 years) food production has tremendously decreased and a family can hardly sustain for 7/8 months on *jhum* food alone. Although, some of these allegations are partly true, did anybody question the reasons behind such a sorry state of this cultivation practice, which was once a self-sustaining one? If shifting cultivation is that bad, how an estimated 10 million hectares of land in South Asia and more in Latin America and Africa continue to be under this form of agriculture? How could majority of more than 400 million people survive on shifting cultivation across Asia these days?

Jhum has become the victim of a concerted policy campaign for last two centuries in this part of the world. It was initiated by British colonial administration and followed by subsequent governments having tremendous impacts on the land use pattern of the Chittagong hills. CHT Regulations 1900 divided the CHT into three circles (Chakma, Bohmang and Mong) with *Raja* as the Circle Chiefs. The whole area was divided into *Mouzas* with Headmen as the *Mouza* chiefs and *Karbaaris* as village chiefs. *Jhum* tax was first introduced. About hundred years back, *Jhum* tax was very high at Tk.4 per *Jhumiya* family (rice used to be sold at Tk1 for 60 kg), meaning at the present rate, *jhum* tax would be around Tk 1000/family (Tripura and Harun, 2003). British administration created deterrence, as *Jhumiyas* were not allowed to cultivate land inside of the protected forests.

Moreover, the very negative attitude of the government and some development partners concerning *jhum* cultivation were reflected in the development projects and policies implemented in the hills. At some point of time, PCJSS Leader, Shantu Larma was asked to comment on the *Jhum* cultivation. He termed this agricultural practice as a damaging one to environment and suggested for its banning after finding out a viable alternative to *Jhum*. (Haque, 2009; Tripura and Harun, 2003). Question arises, despite all these campaigns and propaganda against *jhum* farming, why this "destructive" agricultural practice has been continuing in the CHT and elsewhere in the world even today?

Anti-*Jhum* Projects and Policies

Jhuming was an environmentally-suitable land use in the past, when population pressure on the land was low and the fallow period was long facilitating restoration of vegetation cover and soil fertility. The situation has become environmentally incompatible following shortening of fallow period due to inundation of a vast area by Kaptai Hydro-electricity project, influx of people from the plains, abolition of local peoples' use and management rights of the forests, various faulty development projects and policies discouraging shifting cultivation. Some of the projects and policies are as follows:

a) Kaptai hydro-electricity project created a huge artificial lake covering 650 sq.kms, inundated a vast area of 54,000 acres of plough land (40% of total cultivable land of the area) and displaced 100,000 people, mostly Chakma sedentary rice farmers. The project was commissioned in 1962 to generate 230 MW of electricity. The displaced Chakma rice farmers left for the northern reserve forests and some crossed the borders all the way to Arunachal Pradesh (Haque, 2013; Haque, 2008; Haque, 1995,; and Khisha and Khisha, 2009). Hardly US$ 2.6 million was spent for resettlement of the project affected persons out of an allocation of US$ 31 million. Due to loss of such a fertile rice cultivable area, the sedentary rice farmers were forced to exploit the forest resources and resorted to *Jhum* cultivation. As a result, fallow period of Jhum cycle shortened. Although, the project was designed to produce hydro-electricity, the local community, especially the *Jhumiyas* never received any benefit from this project.

b) Karnaphuli Paper Mill (KPM) at Chandroghona, since its operation in 1953, has consumed millions of tones of bamboo and softwood that came from the forests of the CHT. As the natural stocks of raw materials drastically reduced, two pulpwood divisions were created under the Forests Department to ensure steady supply of raw materials. Unfortunately, the pulpwood plantation was set up on Unclassified State Forest (USF) land, which was the traditional *jhum* land for the local indigenous community. The agricultural practice of the *Jhumiyas* was blamed to establish the rationale for pulpwood plantation. The fast growing, high yielding monoculture plantation species have replaced the natural forests resulting in major environmental and social concern in the CHT (Gain, 2013).

c) Government project to resettle around 3, 75,000 Bengali landless farmers from the plains was another reason for shortening of the cycle (Haque, 1995). In the mid-1979, following a decision to settle landless families from the plains, truckloads of poor landless *Bangalee* families were brought in the hills. They were attracted by the government's scheme to provide five acres of hilly land, four acres of mixed land and 2.5 acres of paddy land for each newly settled family. These poor people were later termed as "settlers"- a derogatory term abhorred by them. Plantation of settlers was a planned political move in order to demographically transform the district. Militarily, the strategy was intended to flash out the *Shanti Bahini* (Peace Corps) guerrillas by denying them access to food and shelter. The official figures reveal that population of the hill/non-hill ratio in the three districts was 91:09 in 1951, 88:12 in 1974, 59:41 in 1981 and 49:51 in 1991 (Haque, 2013).Due to influx of people from the plains, pressure on the meager hilly land increased and the *Jhumiyas* were forced to shorten the *Jhum* cycle. Shifting cultivation cycle in the CHT shortened from 8-10 years in 1960 to 3-4 years in 1990 (Rasul, 2009).

d) Department of Forests established a "*Jhum* Control Board" way back in 1960 to resettle the *Jhumiya* families, victims of Kaptai Hydro project and also to control shifting cultivation. Two projects were undertaken by the Board for containing *Jhum* cultivation, they were: Pilot Scheme for controlling *Jhum* Cultivation; and Model Horticulture Development Project. Huge areas in Bilaichhari and Kash Khali were declared as "Protected Areas" in order to bring them under afforestation and horticulture scheme for resettling the *Jhumiyas*. Under the second project, vast areas of Ramgarh, Rangamati and Chengi Valley were developed into orchards for planting banana, pineapple, cashew nut, papaya, coconut and lemon etc. Six acres of land were allotted to each *Jhumiya* family. However, both the projects failed to control *Jhum* and the *Jhumiyas* left, as a result, the Forest Department planted soft woods over there (Khisha and Khisha, 2009).

e) Since, the Forest Act 1927 was not applicable for the CHT, the Forest Department arbitrarily took various regressive projects like, declaration of "Reserved Forests"; "Protected Forests"; Social Forestry; *Jhumiyas* Resettlement Project etc. in order to discourage the *Jhumiyas* from cultivation of *Jhum* fields. Between 1989 and 1998, the Forest Department declared 2, 17,790 acres of land as "Protected Forests" evicting many *Jhumiya* families (Tripura and Harun, 2003). Advised by Asian Development Bank, "Social Forestry" was adopted to plant 60 lakhs of saplings in 2000 ha of *khas* lands and Unclassified State Forests (USF) under benefit sharing scheme. Under benefit sharing scheme, it was envisaged that out of the total sale proceeds, when matured, Forest Department to get 40%; Beneficiary (40%); Hill Dist Council (5%); Headman (3%); *Karbaari* (2%); and Tree Fund (10%). Rotational period was considered as 40-60 years, which discouraged the *Jhumiyas* to get involved in such a project (Tripura and Harun, 2003, p.37). It was a programme, never materialized, resulting in decreased access of the *Jhumiyas* in *Khas* land. Under the "Afforestation and Rehabilitation of *Jhumiya* families in the USF and Reserved Forests Lands of CHT", the Forest Department undertook afforestation and rehabilitation of *Jhumiya* families in the USF lands and reserved forest lands of CHT. The project received resistance, since the USF land was the traditional land for *Jhum* cultivation. Around 350 *Jhumiya* families with 5 acre of land each were to be rehabilitated there, which later never implemented (Tripura and Harun, 2003). *Jhumiyas* were never nomadic and question of their rehabilitation never arises. Their villages were permanent in nature, no matter they shifted their *Jhum* fields (Rafi and Chowdhury, 2001 and Tripura and Harun, 2003).

f) *Joutha Khamar* (Collective Farming) was initiated during the period of President Ziaur Rahman for socio-economic rehabilitation of the poor and "landless" *Jhumiya* farmers. Aim was to bring the *Jhumiyas* under traditional farming system. The project was undertaken by Chittagong Hill Tracts Development Board (CHTDB) and it was intended to "rehabilitate" 3,487 *Jhumiya* families by providing them with 5 acres of high land each to cultivate pineapple, banana and rubber plantation. The results were disastrous. *Jhumiyas* were not culturally prepared to live in such a collective farm and get involved in horticulture farming. Some of them didn't get their land at all, some sold off their land and left for the wilderness.

g) Funded by ADB, the Rubber plantation was a much ambitious project of the CHTDB. Starting in 1979, some 3,000 *Jhumiya* families were involved in phases under "Upland Settlement Scheme". Each household got 4 acres of land for rubber, two acres for horticulture and .25 acres for homestead (Gain, 2013).The hills chosen were in USF land, the traditional land of the *Jhumiyas*. Rubber plantation was a clear threat to forest, its biodiversity and wildlife. It is a single species monoculture. Although, it looks like a forest from a distance, it is a desert for birds and other wildlife.

Plantation of exotic rubber by completely felling off all indigenous trees, inexperience in rubber cultivation and sapling collection etc turned this project into a disaster.

h) Tobacco cultivation kicked off in the CHT in 1990 and extended like wild fire all over the hills, especially on the river banks, traditional land for rice and vegetables. Among the three hill districts, Bandarban was seriously affected and tobacco cultivation has posed a great threat to traditional agriculture, the food security of the local community and the environment. Invasion of tobacco by the multinational and local tobacco companies also brought chemical fertilizers and pesticides polluting the streams, only sources of potable water. Trees are felled for burning of wood to dry tobacco leaf in traditional *tandur* (oven) has caused massive deforestation of the area. Some of the indigenous communities (notable the *Chaks* in Badurjhiri, Bandarban) were totally wiped off from areas brought under tobacco cultivation by these companies.

i) "Cluster Villages" were set up by Bangladesh Army in the CHT as a part of their counter-insurgency strategy back in 1988. Since most of the camps of *Shanti Bahini* (armed guerrillas wing of PCJSS) were in the dense forests, where *Jhum* cultivation was practiced, Army in order to access the inaccessible parts of the area, set up cluster villages and the *Jhumiyas* were brought in lured by ration and land (Tripura and Harun, 2003; and Khisha and Khisha, 2009). In Bandarban, the *Jhumiyas* were involved in cluster village programme. Most of the *Jhumiya* families left the cluster villages due to discontinuation of ration and other facilities. In 1988, General Officer Commanding (GOC), Chittagong banned *Jhum* cultivation in Khagrachhari and Rangamati districts though official notification. Moreover, *Jhum* cultivation was banned within two-mile radius of every Army camp for "security" reason and there were several army camps scattered all over the CHT controlling lives and living of the hill people.

Present Situation of the *Jhumiyas* in Bangladesh

As stated before, approximately, 41,000 ha of land of this region (14% of total cropped area) is used for *Jhum* cultivation every year and about 73,000 families are engaged in this traditional form of agriculture. According to another study, the number of *Jhumyas* is around 35,000 (Tripura and Harun, 2003). Most of the *Jhumiya* families live in Bandarban, followed by Khagrachhari and Rangamati. Not many studies have been undertaken so far to assess the present socio-economic situations of the *Jhumiyas* in the CHT. A few of them, reveal the fact that conditions of the *Jhumiyas* further worsened due to century-long policies, projects and campaign against *Jhum* cultivation (Rafi and Chowdhury, 2001; Tripura and Harun, 2003; Khisha and Khisha, 2009 and Rasul, 2009). Due to decrease in fallow period, *jhum* cycle shortened and as a result, production decreased. *Jhumiya* families complained that they couldn't survive on the *Jhum* crops alone round the year. A field survey conducted in 5 villages of Bandarban, shows that *Jhum* crops could ensure food security for 24% families for

3 months; 16% families for 6 months; 25% families for 9 months; 12% families for less than a year; and 24% families for a year with little surplus (Khisha and Khisha, 2009). As a result, they collect bamboo bushes and trees from the hills and sell them in the market. As rice yields decreased steadily due to declining soil fertility and shortening of *Jhum* cycle, the *Jhumiyas* started looking for alternative crops for their sustenance. In some areas, horticulture replaced rice, which facilitated transition from a cereal based extensive type of land-use system to a perennial-crop based intensive system (Rasul, 2009). Some get involved as daily labourers for a living. Based on discussions with the *Jhumiya* families, it was known that *Jhum* had lost its charm. *Jhum*, which used to provide everything for them, starting from food, clothing, medicine and shelter has turned out to be a non-functional one. A self-sustaining economy has created dependence and deprivation. *Jhumiyas* and poverty are intertwined. Due to influx of people from the plains and population pressure, land availability decreased, *jhum* cycle shortened and soil fertility lost. *Jhum* fields are usurped by the Forest Department in the name of various projects and programmes. Everybody experimented on the *Jhum* fields, starting from exotic rubber, teak, acacia and finally horticulture.

Sad thing is that in order to increase food production, *Jhumiyas* have resorted to using agro-chemicals, insecticides and pesticides taking tolls on the environment. Earlier days, burned ash of *Jhum* fields was used as insect repellent. Following shortening of *Jhum* cycle, the farmers are now applying more chemical fertilizer (mainly urea and potash) and insecticide (dynochlor, basudin) to get increased production of mainly ginger and turmeric (Tripura and Harun, 2003). *Jhum* fields are now being used to grow turmeric and ginger in an unsustainable way. Some of the multinational companies are making business out of it. Earlier days, *Jhum* crops were used for the family consumption only and the surplus sold off in the market. Now most of the produces is sold in the market, which created increased dependence on the forest products. Collective labour has turned into wage labour and some *Jhumiyas* changed their profession and got involved in small business. New-year festivals like *Bijhu* for the Chakmas, *Boishuk* for the Tripuras; and *Sangrai* for the Marmas, collectively known as "Boisabi" are intertwined with *Jhum* cultivation. Their songs and dances, hopes and aspirations are centered round the *jhum* fields. These cultural festivities are losing their charm, as *jhum* fields are getting smaller and unproductive.

Natural disasters, like excessive rain, drought, invasion of rats and famine were never known in the Chittagong hills. Farmers complained that due to flowering of bamboos, rat population increased causing enormous devastation of the *Jhum* fields. *Jhumiya* women farmers complained that not enough cotton is grown in the field, as a result, they are unable to weave their clothes. They also don't get a fair price for cotton in the market. The farmers are of the opinion that government policies to discourage *Jhum* cultivation were taken without finding out a viable alternative for them. The alternative should be environment-friendly, culturally sensitive, ethnically acceptable and economically profitable.

Jhum happened to be a self-reliant production system for a fringe land community, away from the mainstream society living in a most difficult terrain, where basic amenities are almost non-existent. *Jhumiyas*' strong adherence to traditional values and culture is considered perhaps to be the major factor behind continuation of this age-old system. Moreover, at high altitude steep hills, the farmers couldn't find any other alternative method of livelihood except traditional *Jhuming*, which they knew for generations.

Global face-lift for *Jhum*

While situation of *Jhum* cultivation in the CHT is so dismal and depressing, elsewhere in other shifting cultivating countries of the world, it is much better. As stated before, an estimated 10 million hectares of land in South Asia are currently under this form of agricultural practices. Farmers for centuries have been able to sustain their livelihoods on those lands where farming conditions are most challenging and slopes are steepest. If hundreds of millions of farmers continue to practice it despite all incentives to control, shifting cultivation must make some sense. A common policy approach to discourage shifting cultivation is found across Bangladesh, Bhutan, India Nepal and Myanmar. Current problems related to shifting cultivation are the results of counterproductive policies due to inappropriate land-use practices. Therefore, there is a great need for new, more effective and socially and culturally acceptable policy options in favour of shifting cultivation. Many innovations and indigenous practices introduced by farmers of this region in response to contemporary pressures and restraints are noteworthy. Since the promotion of permanent land use alternatives is not having the desired result, farmers' own innovations might be able to pave the way to overcome the current crisis.

Most of the countries undertook policies to do away with shifting cultivation and replace it with permanent forms of agriculture and forestry. Results were disappointing. Some farmers have tried out the alternatives, but couldn't sustain them. Traditional practices are discouraged, while alternatives provided are often not working.

Farmers' Innovations

International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal conducted a number of case studies, which show that shifting cultivation as a farming system provides benefits both for its practitioners and for the society. The findings demonstrate that shifting cultivation contributes to forest cover, wild life conservation, agro-biodiversity, soil and water conservation, organic farming as well as cultural integrity and social security (Kerkhoff, 2006).Some of the major findings are elaborated below:

a) **Forest Cover:** Forest fallows are the most important part of the farming system, and the main source of productivity. Following is a common agricultural practice all over the world. It is defined as "allowing crop land to lie idle, either tilled or untilled, during the whole or a greater portion of a growing season" or land rested from deliberate

cropping, not necessarily without cultivation or grazing but without sowing (Kerkhoff, 2006). Fallows are used to rest and revitalize soils after cropping. Far from being "abandoned" land, these fallows are actively managed by farmers and used for various purposes. Land left fallow is actually part of the whole *Jhum* cycle and needs to be protected as *Jhum* land and not to be treated as a "wasteland". The fallow management starts during the land clearing, as many communities protect selected trees against the burning. They further intercrop and maintain trees during the cropping phase to enhance re-growth of preferred species in the fallow. Selected patches are maintained to protect water sources and to serve ecological and religious purposes. Controlled burning is a useful management tool. Maintenance of fallow forests creates higher forest cover and biodiversity than permanently cultivated land or tree plantation. For the management of plot rotation and distribution, the crop/fallow sequence is translated in terms of area. For example, if the shifting cultivation cycle is a total of eight years, with two years cropping and six years of fallow phase, a farmer will in any one year have on average two plots under cultivation and six plots under fallows of different ages.

b) **Wild life Conservation:** The community-level land use planning and forest management in rotational agro-forestry benefit biodiversity and certain wildlife species. The patchy landscape resulting from rotation in itself is more diverse than continuous primary forests. Furthermore, wild elephants and other large migratory mammals need access to large spaces with grassy vegetation as well as patches of bamboo and more dense forests. Due to their migratory habits, they often cause a threat to sedentary farmers, while rotation practiced in shifting cultivation enables people and elephants to use the same resources at different times. If elephant conservation was taken up in these areas, the cycles could be made long enough to allow different habitats they require.

c) **Agro-Biodiversity:** Rotational agro-forestry system across the region is richer in agro-biodiversity than modern farming systems (which often depend on mono-cropping). Due to rotational fallows and controlled burning, *jhum* fields get enriched in biodiversity. Additionally, there are intricate intercropping, relay cropping and tree intercropping practices, which greatly contribute to diversity. In some areas, crops like rice are more prevalent in the first two years, while maize and millet are more prominent in subsequent years. In the later years, farmers plant more nutrient-efficient crops that are able to compete with weeds (Tripura and Harun, 2003).

d) **Soil and Water Conservation:** In soil and water conservation, useful practices and innovations exist such as contour bounding using logs or bamboo poles. Dibbling is a technique, where farmers dig a small hole with a long knife or pointed stick, after which, they throw seeds. It is a form of minimum tillage, which is important for erosion prevention on sloping land.

e) **Organic Farming:** Shifting cultivation also promotes organic farming, as the farmers use decomposed leaves as green manure and compost. Burned ashes act as natural insecticide against all insect attack. Although in some areas of the CHT, Bangladesh, agro-chemicals are used by the farmers for increased crop production in *Jhum* fields, the practice could be avoided with the help of integrated pest management. Intercropping, sequential cropping make sense for reducing the risks of market dependency, efficient land use, soil conservation and weed control.

f) **Cultural Integrity and Social Security:** Shifting cultivation is a way of life. Customary institutions are essential for shifting cultivators to manage their farming system as a community. Shared norms, values, traditions, beliefs, religion, rules, regulations, laws, civil society organizations and government agencies are all parts of the institution. All of these influence the management of natural resources in shifting cultivation. There is no "open space" but rather a common property regulatory system, based on extensive knowledge and customs of the locality. A major function of customary authorities is the annual land allocation of plots to families, within the common property, in line with land capability and family size. Similarly, fire management, efficient use of collective labour requires strong social organizations.

The innovation and practices need to be piloted, shared and exchanged with other shifting cultivators. Success stories elsewhere to be documented and shared among the farmers. Only a favorable policy environment and policy direction could foster such practices in bringing about a much-desired paradigm shift.

Shillong Declaration, 2004

At the Regional Shifting Cultivation Policy Dialogue Workshop for Eastern Himalayas held in October, 2004 In Shillong, India, representatives of government agencies, farmers, international bodies, NGOs, academia, science and research institutions, donors and private sector people adopted the "Shillong Declaration" and formulated concrete policy recommendations based on the research findings of this initiative (Kerkhoff and Sharma, 2006). Terming shifting cultivation as a "way of life" for a large number of indigenous, tribal and other poor and marginalized upland communities, they urged the governments and policy makers to recognize *Jhum's* immense utility and to shift policy from its current emphasis on "weaning away" hill farmers from a "primitive" style of cultivation. *Jhum* cultivation was pronounced "good for the environment, livelihoods, biodiversity conservation and food and social security".

They recommended that the policy makers should recognize tenure rights of the shifting cultivators. They urged upon the governments and the policy makers to recognize shifting cultivation as an agricultural and an adaptive forest management practice based on scientific and sound ecological principles. They emphasized on empowering the shifting cultivators as

practitioners of rotational agro-forestry to become active participants in decision-making and policy processes that impact them the most.

The farmers at the workshop observed that *Jhum* cultivators conserve the forests and make it productive at the same time. *Jhumiyas* nurse and nurture forests back into their *Jhum* fields, while conventional farmers banish the forest from their fields. The basic philosophy of shifting cultivation has been to create forests and not to destroy forests, for without forests, the next *Jhum* cannot be cultivated. *Jhum* conserves, biodiversity; it is a storehouse of innovative organic farming practice; and supports continuity of social institutions, traditions, customs and tenure systems in the hill societies.

Conclusions

Jhum cultivation is a farming system mired in misunderstanding. For years, it has been seen by governments and development partners as an anachronistic, outdated and destructive practice-summarized in the negative phrase of "slash and burn". Counter-productive policies, ambitious development projects, inappropriate land use practices, shortening of *Jhum* cycle, century-long anti-*Jhum* campaign-all contributed to the present sorry state of shifting cultivation not only in Bangladesh, but also elsewhere in the world. Various agencies of the government, specially the Department of Forests continue to create havoc with new and periodic experimental projects in the highlands. The other government agencies also compete for a space, terming the hills as empty. A study conducted by Anti-slavery Society in 1967, concluded that the "emptiness of the hill tracts is a myth". The study further said, as far as its developed resources are concerned, the hill tracts are as constrained as the most thickly populated districts in other parts of Bangladesh (Anti-Slavery Society, 1984, quoted in Haque, 1997). Considering the hills as barren and "unproductive" landmass, all development agencies view with each other for implementation of their own brand of development projects. Rubber plantation replaced the *Jhum* land, rubber factories sprang up in the hills, artificial reservoir created by damming huge area for generation of hydro-electricity putting pressure on the *Jhum* lands- these are the activities already put tremendous pressure on limited *Jhum* lands and the onslaught continues.

Against all odds, surprisingly around 73,000 *Jhumiya* farmers in Bangladesh and around 400 million around the globe continue practicing *Jhuming*, which demonstrate that there must be some merits in *Jhum*. The steep slopes of the hills could only be utilized for agro-forestry- a wakeup call for the policy makers and extension workers.

The greatest challenge would be how to change the anti-*Jhum* mindset created among the policy makers, development workers, foresters, agricultural scientists, extension workers and the academia? A decade-long campaign through print and electronic media is needed to change the mindset so long created through century-long concerted campaign. Piloting some agro-forestry *jhum* projects could be taken in earnest. It is high time that the policy makers, development practitioners, extension workers and the farmers sit together to pilot innovations

and various indigenous practices adopted by the shifting farmers globally. Only sincere commitment and hard work with devotion may be able to salvage this age-old agricultural practice and the farmers out of the quagmire so long created by the policy makers and the development practitioners.

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Existing and Impending Selectable Marker Genes for Banana Genetic Transformation Researches: A Review

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Abstract

Banana plants are becoming worriedly susceptible to newly emerging pathogens and environmental stresses. Since edible bananas are vegetatively propagated they are incapable of genetic modification of their genome, therefore, genetic modification could be the only way out of this vulnerable situation. Success of genetic improvement largely depends on the efficient identification and isolation of transformed cells and selectable marker genes (SMG) are applied to serve this purpose. Two antibiotic resistance genes hygromycin phosphotransferase (hpt) and neomycin phosphotransferase (nptII) and one herbicide resistance gene acetolactate synthase (ahas/als) of bacterial origin were found to be used in banana genetic transformation researches by a number of scientists. The presence of antibiotic resistance genes or SMGs in commercialized transgenic plants (released varieties) is not allowed in many countries due to biosafety regulations and negative public concern. The risk of gene flow and horizontal gene transfer leading to increased antibiotic and herbicide resistance in nature is also a major disquiet therefore in search of potential SMGs for banana transformation research only alternative selectable markers genes were searched and incorporated in this review.

Introduction

Over 100 countries throughout the tropical and sub-tropical regions of the world cultivate bananas (Sharrock S. and Frison E., 1999; http://bananas.bioversityinternational.org/files /files/pdf/ publications /focusen_production.pdf). More than 400 million people in many of these countries such as Honduras, Cuba, Philippines, Uganda, Ethiopia, Burundi, Rwanda, India, Ecuador, Brazil, Colombia, China, Indonesia, Democratic Republic of Congo, Costa Rica and many others use banana and plantain as their major staple food and approximately one billion people around the globe eat this fruit daily (http://www.fao.org/docrep/007/ae216e/ae216e02. htm).

Alongside its importance, banana production is threatened greatly by several diseases and pests. The most devastating fungal diseases of banana are the Fusarium wilt or Panama disease which causes serious damage to the plants and black Sigatoka alone can result in yield loss up to 50%(Ploetz, 2001). Nematodes, banana weevil and several viral diseases such as banana bunchy top virus (BBTV), banana streak virus (BSV) and banana bract mosaic virus (BBMV) also exert great constraint for banana production. Chemical control of these diseases is

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expensive and in case of some diseases it is not even applicable due to lack of effective chemical (Bakry *et al.*, 2009) hence breeding banana for resistance is the only viable strategy.

Conventional cross breeding of banana is extremely difficult and time-consuming (Rowe Rosales, 2000). Cultivated, edible banana varieties are seedless and mostly sterile (Heslop-Harrison and Schwarzacher, 2007). The absence of sexual reproduction makes vegetative propagation the only way to multiply banana and implies the absence of new recombination in its genome. With its DNA more or less frozen in time, this plant cannot easily adapt to a changing environment or newly emerging devastating virulent diseases through natural recombination. Therefore, it is unavoidable and equally important to improve this plant using genetic engineering.

Genetic manipulation of plants is a time-consuming, expensive and labor intensive process. Several steps are necessary before genetically engineered plants can be obtained, such as identification and isolation of one or more genes of interest (GOIs), cloning GOIs into a transfer vector, transformation of the host cells and integration and expression of the GOIs in the host genome. Using even the most successful plant transformation methods only a small fraction of the targeted cells will incorporate the GOIs into their genomes (Miki and McHugh, 2004). Therefore, it is essential to have a system which allows differentiation between transformed and untransformed cells. Selectable marker genes (SMGs) can be expressed in wide range of cell types and their expression allows the transformed cells to grow in presence of the corresponding selective agent while untransformed cells are either retarded in growth or unable to survive. Usually these genes are constitutively expressed in the transgenic cells or plants and co-transformed as a chimeric gene with one or more GOIs.

Existing Conditional Positive Selectable Marker Genes Used in Banana Genetic Engineering Researches

In banana only conditional positive SMG systems were (Table-1) found to be used for transformation researches. Conditional positive selection systems consist of a gene – usually encoding for an enzyme – that confers resistance to a specific substrate (an antibiotic, a herbicide, a drug, a metabolite analogue, a carbon supply or a phytohormone precursor) that is either toxic to the untransformed plant cells or facilitates the growth as well as differentiation of the transformed cells alone. Conditional positive selection systems used in banana are discussed below:

Antibiotic Selectable Marker Genes

Hygromycin Phosphotransferase (hpt)

The *hygromycin phosphotransferase* (denoted *hpt, hph* or *aph*IV) gene was originally derived from bacteria *Escherichia coli.* The gene codes for hygromycin phosphotransferase (HPT), which detoxifies the aminocyclitol antibiotic hygromycin B. A large number of plants

have been transformed with the *hpt* gene and hygromycin B has proved very effective in the selection of a wide range of plants, including monocotyledonous.

Ghosh *et al.*, 2009 studied establishment of embryogenic cell suspension cultures and *Agrobacterium*-mediated transformation in an important Cavendish banana cv. Robusta (AAA). The T-DNA contained CaMV 35S promoter driven *gusA* gene interrupted by a modified castor bean catalase intron and double enhanced 35S promoter driven *hpt*II gene conferring resistance to hygromycin. After transformation in 5 mg/L hygromycin and 30 independent lines/50 mg fresh weight samples were obtained.

Centrifugation assisted *Agrobacterium tumefaciens* mediated transformation (CAAT) of embryogenic cell suspensions of banana (*Musa* spp. Cavendish AAA and Lady finger AAB) conducted by Khanna *et al.*, 2004 was another experiment where *hpt*II gene under the control of CaMV 35S promoter was used and 30 mg/L hygromycin was used as selective agent, after transformation 25-65 plants per 50 mg fresh weight embryogenic cell suspensions were obtained.

*Neomycin Phosphotransferase*II (*npt*II)

The *neomycin phosphotransferase* II (*npt*II) gene is the more widely used. It was initially isolated from the transposon Tn5 that was present in the bacterium strain *Escherichia coli* K12. The gene codes for the aminoglycoside 3'-phosphotransferase (denoted aph(3')-II or NPTII) enzyme, which inactivates by phosphorylation a range of aminoglycoside antibiotics such as kanamycin, neomycin, geneticin, and paromomycin.

In banana transformation researches *npt*II was expressed under nos, 35S and EFE promoters (Khanna *et al.*, 2004; Pérez Hernández *et al.*, 2006; Huang *et al.*, 2007; Kumar G. B. S. *et al.*, 2005). Table-1 illustrates different selectable marker gene, selective agents and their concentration used in banana transformation studies. Banana embryogenic cell suspension (ECS) cultures were used for transformation in all the experiments, differences were found in the applied selective agents and their concentrations as well as the obtained stable transformation frequencies (Table-1).

For *npt*II gene and *Agrobacterium*-mediated transformation systems kanamycin (50-100 mg/L) or geneticin (50 mg/L) were used as selective agent.

In particle bombardment mediated transformation experiments (Table-1) kanamycin (100 mg/L) and geneticin (50 mg/L) were used and the range of transformation frequency varied between 11% - 90% in those experiments. Moreover, it was also found that geneticin is the most effective selective agent for the *npt*II SMG as banana cells are naturally insensitive to kanamycin (Pérez Hernández *et al.*, 2006).

Table-1: Selectable Marker Genes, Selective Agents and their Concentration Used in Banana Transformation Studies

Selectable Marker Gene (SMG)	Promoter Driving the SMG	Banana Variety (genomic group)	Selective Agent	Concentration of Selective Agent (mg/L)	Transformation Frequency (No of independent lines/50 mg fresh weight sample)	Reference
Agrobacterium - Mediated Transformation						
ahas/als	ubi1	Rasthali (AAB)	chlorsulfuron (Glean™, DuPont)	0.005	40	Ganapathi *et al.*, 2001
hpt	enhanced 35S	Robusta (AAA)	hygromycin	5	30	Ghosh *et al.*, 2009
	35S	Grande Naine (AAA) Lady Finger (AAB)	hygromycin	30	25-65	Khanna *et al.*, 2004
nptII	nos	Lady Finger (AAB) Grande Naine(AAA)	kanamycin	50	25-65	Khanna *et al.*, 2004
	nos	Three Hand Planty (AAB)	geneticin	50	25-50	Pérez Hernández *et al.*, 2006
	35S	Mas (AA)	geneticin	50	65	Huang *et al.*, 2007
	EFE	Rasthali (AAB)	geneticin	5	50	Kumar G. B. S. *et al.*, 2005
Particle Bombardment						
ahas/als	ahas	Maçã(AAB)	imazapyr	261.28	4.6	Matsumoto *et al.*, 2002, 2007
	35S	Bluggoe(ABB)	hygromycin	50	1-3	Sági *et al.*, 1995
nptII	enhanced 35S	Maçã(AAB)	kanamycin	100	3.1	Matsumoto *et al.*, 2002
	BT6.3 35S	Grande Naine(AAA)	kanamycin	100	24	Becker *et al.*, 1999
ND	nos	Three Hand Planty (AAB) Bluggoe (ABB) Williams (AAA)	hygromycin, geneticin	50 50	2-10	Remy *et al.*, 1998; Remy, 2000

als - acetolactate synthase gene; *ahas - acetohydroxy acid synthase* gene; nos - nopaline synthase; Ubi1–ubiquitin1; *npt*II- *neomycin phosphotransferase* gene; BT6.3 - BBTV DNA-6 promoter; *hpt* or *hph- hygromycin phosphotransferase* gene; 35S - CaMV 35S promoter; EFE - ethylene forming enzyme; ND – no data

From table-1 it is also obvious that in the meantime embryogenic cells of different banana cultivars were stably transformed by independent research groups indicating that both systems can be used for banana transformation but in recent banana researches, *Agrobacterium* - mediated transformation system and antibiotic resistance SMGs were found to be most widely used.

Other Conditional Positive Selectable Marker Genes

So far, only *acetolactate synthase* (*ahas/als*) gene of bacterial origin conferring resistance to herbicides is used as SMG in banana research. In different experiments a gene encoding a mutant *acetolactate synthase/acetohydroxy acid synthase (ALS/AHAS)* (Table-1) was used for selecting transformed cells of the banana cultivars 'Rashthali' (Ganapathi *et al.*, 2001) and 'Maçã' (Matsumoto *et al.*, 2002 and 2007). Ganapathi *et al.*, 2001 used *als* which is originated from *E.coli*, having serine at position 100- in one-letter amino acid notation and insensitive to sulphonylureas herbicides as SMG.

Impending SMGs for Banana Transformation

Antibiotic resistance and different microbial genes are most frequently used along with herbicide resistance SMGs (Miki and McHugh, 2004). The presence of these genes in commercialized transgenic plants (released varieties) are not allowed in many countries due to biosafety regulations and negative public concern. The risk of gene flow and horizontal gene transfer leading to increased antibiotic and herbicide resistance in nature (Rieger *et al.*, 1999), the emergence of super weeds and endangering the natural ecosystems (Kulikov, 2005; Miki and McHugh, 2004) are some of these concerns. In the case of the sterile edible bananas the risk of gene flow is nearly nil. To address these socio-environmental issues it is, even for banana, essential to look for new and more environmentally safe selection systems, which are mostly dependent on the manipulation of plant metabolic pathways using mutated plant genes as selection markers (Leyman *et al.* 2004, 2006; Mentewab and Stewart, 2005).

Selection and use of effective SMGs for genetic modification depend on a number of parameters and variations may be observed in efficiency of a particular SMG in different systems. Efficiency is determined by the capability to distinguish between transformed and non-transformed cells and is expressed by the stable transformation frequency. Efficiency can be affected by several parameters like the origin of the SMG, the promoter used for its expression, the transformation method, the type of selective agent used and its concentration or the genetics of the host. Considering all the above mentioned criteria, following SMGs could be chosen to evaluate their efficiency in banana transformation.

Mutated *Acetolactate synthase* (*ALS*) Genes (plant origin)

Acetolactate synthase (ALS) also known as acetohydroxyacid synthase (AHAS, E.C. 4.1.8.13), is the first enzyme in the biosynthetic pathway for synthesis of branched chain amino acids

leucine, isoleucine, and valine in fungi, bacteria and plants (Chipman *et al.*, 1998). ALS catalyses two distinct reactions in this pathway the condensation of two pyruvate molecules to form acetolactate, which is an intermediate for the synthesis of valine and leucine, and the condensation of pyruvate and α-ketobutyrate to form acetohydroxybutyrate as an intermediate for isoleucine synthesis (Chipman *et al.*, 1998; Singh, 1999). ALS is inhibited by several chemicals which are active ingredients in different herbicides like imidazolinones (IMIs) (Sathasivan *et al.*, 1991), sulfonylureas (SUs), pyrimidinylcarboxylates (PCs), triazolopyrimidines (TPs), sulfonylamino-carbonyl-triazolinones (SCTs) (Shimizu *et al.*, 2002) and pyrimidinylthiobenzoates (Singh and Shaner, 1995). Several plants have been isolated in which herbicide resistant characteristics were due to one or two point mutation in the ALS enzyme (Table-2). Through these mutations the interaction between the herbicides and the ALS was altered that resulted in herbicide resistant plants e.g. chlorsulfuron-resistant tobacco due to a point mutation in *A. thaliana csr1-1* gene resulting a substitution of amino acid proline to serine at position 197 (P197S) (Haughn *et al.*, 1988), bispyribac resistant rice due to substitution of tryptophan 548 to leucine (W548L) and serine 627 to isoleucine (S627I) in rice*als* gene (Osakabe *et al.*, 2005) and pyrimidinylcarboxylates (PC) resistant rice because of tryptophan 548 to leucine (W548L). Imazapyr resistant soybean due to serine 653 asparagine (S653N) substitution in *A. thaliana als* gene (Aragão *et al.*, 2000).

Table-2: Mutated *Acetolactate Synthase* (*Als*) Genes from Rice *A. Thalianaand* Maize Used as Selectable Marker Gene for Transformation in Different Plants

Als Gene	Origin *Als* Gene	Host (Plant Transformed)	Promoter Driving *Als*	Selective Agent	Concentration (µm)	Stable Transformation Frequency (%)	Reference
osals	rice	rice	als, 35S	bispyribac sodium salt	0.5	ND[a]	Osakabe K. *et al.* 2005
als	*A. thaliana*	soybean	als	Imazapyr	0.5	3.9 to 20.1[b]	Aragão *et al.*, 2000
csrl-1	*A. thaliana*	rice	35S	chlorsulfuron	0.01	ND	Li *et al.*, 1992
als	*A. thaliana*	winter jujube	35S	chlorsulfuron	1.4	5.2[c]	Gu *et al.*, 2008
als	*A. thaliana*	*B. juncea* (Oilseed mustard)	35S	chlorsulfuron imazethapyr	0.0055 0.0002	4.6[d] 7.8[d]	Ray *et al.*, 2004
als	maize	maize	35S	chlorsulfuron	2.8	5.17[e]	Yang*et al.*, 2006

als – acetolactate synthase; 35S - CaMV 35S promoter; *csrl-1*- mutated *A. thalianaals* gene; *OsALS* - mutated *riceals* gene; ND – no data *Agrobacterium* mediated transformation of - [a] rice callus; [c] shoot tip; [d] hypocotyls; [e] maize callus; [b] particle bombardment of apical meristem of embryonic axes.

Mutated *Anthranilate Synthase* (*AS*) Genes

Anthranilate synthase (AS, EC 4.1.3.27) catalyzes the first step of tryptophan synthesis *i.e.* the conversion of chorismate to anthranilate in the shikimate pathway (Radwanski and Last, 1995; Li and Last, 1996). Tryptophan (Trp) is an essential aromatic amino acid for protein formation in plants and microorganisms and major source of the indole ring for the synthesis of important compounds e.g. auxins, glucosinolates, nicotinic acid, phytoalexins and alkaloids (Haslam 1993).

Table-3: Mutated *Anthranilate Synthase α-subunit (asa)* Genes from Rice and Tobacco Encoding a Feedback Insensitive AS Successfully Used as Selectable Marker Gene for Plant Transformation

Asa Gene	Origin of *Asa* Gene	Host (Plant transformed)	Promoter Driving *Asa*	Selective Agent	Concentration (μM)	Stable Transformation Frequency	Reference
oasa1d	rice	potato	35S	5MT	150	ND	Matsuda *et al.*, 2005
		potato	35S	5MT	100	70%[a]	Yamada *et al.*, 2004
		rice	Ubi	5MT	300	6.9%[b]	
		rice	Ubi	5MT	300	ND	Wakasa *et al.*, 2006
	rice	rice	Ubi	5MT	150	15%[c]	Komatsu *et al.*, 2006
oasa1 and oasa2	rice	rice	Ubi	5MT	300	30%–70%[b]	Tozawa*et al.*, 2001
asa2	tobacco	tobacco	35S	4MI	300	14%[d]	Barone and Widholm, 2008
				7MT	300	7.4%[d]	
asa2	tobacco	Astragalussinicus soybean	35S 606ASA2	5MT	25 15	ND[e]	Cho*et al*, 2004

oasa1d – feedback-insensitive *anthranilate synthase (AS) α -subunit* gene of rice; 5-MT: 5-methyltryptophan; 4-MI – 4: methylindole; 7-MT: 7-methyl-DL-tryptophan; 35S - CaMV 35S promoter; Ubi –maize ubiquitin promoter; ND – no data. *Agrobacterium* mediated transformation of - [a] stem inter node tissues of potato;[b] rice seed callus; [d] tobacco leaf disk; [e] hairy roots. Whisker mediated transformation of [c] rice seed callus.

Plant AS is heterotetramer consists of two distinct α- and β-subunits. The subunits are encoded by separate nuclear genes, translated in the cytosol with plastid-targeting transit peptides (Crawford, 1989; Radwanski and Last, 1995) and are finally processed, folded and localized in the plastids (Poulsen *et al.*, 1993; Romero *et al.*, 1995).

A number of mutant cell lines have been selected resistant to toxic Trp analogues containing a mutated *ASα-subunit (asa)* gene resulting in a feedback insensitive forms of *AS* (Widholm 1972; Carlson and Widholm 1978; Ranch *et al.* 1983; Wakasa and Widholm 1987; Kreps and Town 1992; Li and Last 1996; Tozawa *et al.*, 2001). Naturally occurring feedback insensitive

tobacco *asa2* was used to transform *Astragalussinicus*, soybean; the rice *oasa1d* and *oasa1* mutantgene containing an aspartate to asparagine substitution at amino acid residue position 323 was (Tozawa *et al.*, 2001) used to transform potato and rice. After transformation with such altered AS α subunit genes, transformed cells were selected on medium supplemented with Trp analogues (see below). Uptake of the Trp analogue blocks the shikimate pathway of untransformed cells moreover, the cells cannot incorporate the Trp analogues into proteins (Sasse *et al.*, 1983) and the Trp analogue acts as a false feedback inhibitor of AS resulting in Trp starvation. Eventually, untransformed cells die since Trp is an essential amino acid. Growth of transformed cells is not affected by the Trp analogues due to the presence of a feedback insensitive AS, which results in an uninterrupted Trp biosynthesis and hence, an elevated level of free Trp. A number of transgenic plants expressing a feedback insensitive *asa* gene like *Arabidopsis thaliana* (Li and Last, 1996), Catharanthus roseus (Hughes *et al.*, 2004), tobacco (Tsai *et al.*, 2004), rice (Tozawa *et al.*, 2001; Wakasa *et al.*, 2006), soybean (Ishimoto *et al.*, 2010) and potato (Yamada *et al.*, 2004; Matsuda *et al.*, 2005) showed a 3 - 430 fold higher amount of Trp than the wild types. No phenotypic or pleiotropic effects of this increased Trp content were reported.

Mutated *AS α-subunit* genes from tobacco and rice were tested as SMG in several plants (Table-3) andproved comparable to antibiotic resistance SMGs to distinguish transformed from untransformed cells. Different concentrations of 5-methyltryptophan (5MT) ranging from 100-300 µM was used for selection of transformants but for legumes lower concentration of 5MT was found effective as selective agent (Cho *et al.*, 2004).

Barone and Widholm (2008) used 300 µM of 4-methylindole (4MI) or 7-methyl-DL-tryptophan (7MT) as selective agent for tobacco. A wide range of transformation frequencies (7.8% - 70%) were found in those experiments and varied plant parts or callus cultures like stem internode tissues of potato, soybean hairy roots, leaf disc of tobacco, rice calli were used for the generation of transformants (Table-3). Mostly 35S and ubi promoters were used for the expression of the SMGs and transformed through *Agrobacterium tumefaciens* mediated transformation, except Komatsu *et al.*, 2006 used whisker mediated gene transfer method for transformation of rice callus. Altogether these results demonstrate that selection based on a mutant *asa* gene in combination with a Trp analogue as selective agent could be considered as an effec tive alternative for bacterial originated antibiotic or herbicide resistance SMGs. The rice *oasa1d* gene was selected for testing in banana at the Laboratory of Tropical Crop Improvement and cloning this gene in banana transformation vectors was one of the aims of this thesis work.

Trehalose-6-P synthase (TPS)

Plants are sensitive to high glucose concentration and become pale, white and small when grown under such condition (Avonce *et al.*, 2004). *At TPS1* (*trehalose-6-P synthase* gene of Arabidopsis) over production in plants leads to sugar insensitivity because of its role in sugar

metabolism as well as increased drought tolerance in Arabidopsis. Arabidopsis flower (flower dip) and tobacco leaf discs were transformed using *Agrobacterium* with *At TPS1* over expressed under 35S promoter by Leyman B. *et al.* (2006). Transformation frequency was one percent was obtained and the regenerated transgenic plants, Arabidopsis (at germination) or tobacco (up to shoot regeneration) show less glucose sensitivity (up to 5% -7%). This enables efficient separation of transformed cells from the untransformed ones. *At TPS1* is a plant gene and requires nontoxic glucose for selection of transformants and thus can be considered as a potential selectable marker gene.

5-enolpyruvylshikimate-3-phosphate synthase (epsp)

The enzyme EPSP synthase [EPSPS; (EC 2.5.1.19)] also known as 3-phosphor shikimate 1-carboxyvinyl transferase, catalyzes the formation of 5-enol-pyruvoylshikimate 3-phosphate (EPSP) from phosphoenol pyruvate (PEP) and shikimate 3-phosphate (S3P) in the shikimate pathway for the production of chorismate-derived aromatic amino acids (Pansegrau *et al.*, 1991). Glyphosate, the active ingredient in Roundup herbicide inhibits this enzyme blocking the shikimate pathway and thus secondary metabolites formation in plants. However, mutations in this enzyme can make it resistant to glyphosate (Sikorski, 1997). Howe *et al.* (2002) produced glyphosate-tolerant fertile transgenic maize plants using a maize *epsp* gene as a SMG. Whether the *epsp* gene is suitable for banana transformation has not been tested yet.

Conclusion

This review tried to explore the selectable marker genes so far have been used and potential candidate SMGs which could be used in banana transformation studies. Examination of the scientific literature revealed that a large number of selectable marker genes exist, but only three have been adopted for wide use in researches. Antibiotic resistance genes are not allowed to remain in transgenic plants in many countries therefore it is of utmost importance to search for an alternative SMG most like from plant origin. Some herbicide resistance SMGs are found promising to be used in banana genetic transformation studies.

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Carbon Finance and Low Carbon Economy for Building a Low Carbon Society in Bangladesh: A Review

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Abstract

Global Warming has been challenging the earth's atmosphere since the formation of earth. This has caused mother nature to be defensive and unpredictable. Due to the high pollution, it is becoming more challenging for mother nature to control the environment. Therefore, building low carbon economy is a solution to tackle global warming and achieve sustainable and safety environment. Using the theory, "Survival of the fittest" by Charles Darwin, some countries are in a better defensive position. There are third world countries such as Bangladesh, India, and Nepal who are not prepared for these kinds of challenges. It is essential for these countries to build and maintain low carbon atmosphere. It will be a difficult task to accomplish, but it will give them an opportunity to survive. The goal of this review is to provide a preliminary vision of possible low carbon society in Bangladesh and some important factors which are related with carbon emission.The study may lead to further methodological and conceptual improvement of the environmental sectors of Bangladesh and other vulnerable countries.

Introduction

Climate change is a major development issue that needs to be addressed urgently. Unless global warming slows down, the incident of droughts and floods will likely to increase, vector-borne diseases will probably expand their reach, and many ecosystems, such as mangroves and coral reefs, will likely be put under great pressure. In short, achievements in the fight against diseases, hunger, poverty, and environmental degradation risk being unraveled by climate change. (UN Millennium Project, 2006)

Global Climate effects have become an important issue for the mankind to be concerned. Therefore, countries are trying to adapt to a new development model called low carbon society to fight the climate change. Bangladesh is one of the most vulnerable to these changes. Geographically, it is situated in a critical area where great Himalayas is in the north, and the Bay of Bengal in the south. It is bordered by India on the east, west, and north, and a tip of Myanmar is in the south eastern part. It lies below C-line to the river deltas of the Ganges,

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Meghna, and Brahmaputra. Bangladesh is the eighth most populated country with the population of nearly 160 million people, (Population Census, 2011) and the 9th most densely populated country with 1099 person/km^2. Bangladesh is known as one of the poorest countries in the world due to famine (Hartmann and Boyce, 1983).It has an area of 144,000 square kilometers; it extends 820 kilometers north to south and 600 kilometers east to west. Formally, it has been recognized by the United Nations as a least developed country (LDC), reflecting its low income, week human assets, and economic vulnerability.

Due to the natural disasters such as flooding and earthquake that has occurred in past decade, countries are becoming more careful and making an effort to overcome these problems. Bangladesh is progressing toward the same goal by reaching to low carbon economy. Therefore, it is important to study and understand the concept carbon finance due to energy consumption and low carbon economy. In Bangladesh, very limited research has been conducted on this issue. One of the study has provided some simple projections for Bangladesh's future carbon dioxide emissions which concluded that the consumption of fossil fuel has been increased by more than 5 percent per year during 1977 to 1995 (Azad *et al.*, 2006). By using the population and GDP growth, another research result led to the assumption that impact of development on carbon dioxide emissions in 2050 in Bangladesh (BDRWPS, 2010).An initial vision of possible low carbon society scenario in Bangladesh, which consists for future changes in demography, transport, industry, energy demand and carbon dioxide emission in 2025 (LCS, 2011). Therefore, the target of the current review is to analyze these important factors which are related to carbon emission and develop a low carbon society in Bangladesh.

Methodology

The review was carried out based on secondary sources of information. Secondary information was gathered from: published articles, books, journals, reports, Bangladesh Bureau of Statistics (BBS), and different ministries websites. Primary sources of information are limited to personal observation to strengthen the quality of the paper.

Review of Literature

Defining carbon finance: Carbon finance is a branch of environmental science that built on the basis of a low carbon economy, financial market activities and the related strategy (Zeng and Shuai, 2011). According to the World Bank, carbon finance is the general term used for resources provided to a project to purchase greenhouse gas (GHG) emission reduction. Also, it covers up market solutions to climate change and explores the financial implications of living in a carbon-constrained world. This world carries where emissions of carbon dioxide and other greenhouse gases carry a price (Labatt and Rodney, 2007). In recent years, the availability of carbon finance has created opportunities for entrepreneurs who are developing sustainable energy projects (Disch *et al.*, 2010).

Carbon finance is closely related with the clean development mechanism (CDM) projects. The CDM is the key avenue by which developing countries can participate in the carbon market. They are certified emission reductions (CERs) arising from CDM projects and emission reduction units (ERUs) arising from joint implementation (JI) projects. As of June 2009, the CDM has registered 1665 projects and expects to generate 1.6 billion tons of CERs from currently registered projects by 2012 (CDM, 2009). The Kyoto Protocol creates JI and the CDM to support investments projects which lessens carbon emissions in industrialize and developing countries (Kyoto Protocol, 1998). The carbon finance helps to price the carbon emission allowances, manages emissions price risks, and provides funding for the CDM projects. An example would be $1 of carbon finance leverages $3.80 of underlying investment on average and $9 of underlying investment in renewable clean energy sector (Zoellick, 2008).

There are various kinds of risks exist in the carbon finance like policy which may occur at both international and national level. Also, market and material risks are known as non-delivery; which represents risks arising from the project planning, construction and operations (Heng, 2009).

Carbon Emission and its Effects in Bangladesh

According to the International Monetary Fund (IMF, 2010) Bangladesh is graded as the 44th largest economy in the world with the gross domestic product of US$257 billion, if the purchasing power parity (PPP) is taken into account. Bangladesh is mainly agriculture based economy though the contribution of agriculture to the country's GDP has been gradually turning down from 55% (1970) to 31.6% in 1999 and 21.7% in 2009 (World Bank, 2009). Agricultural productivity will be severely affected by climate change and can make threats to millions of poor people.

The mist resolving of energy crisis is severe in Bangladesh. In 2010 about 47% of the total population has access to the power supply. The government's power supply master plan of 2005 measured that about 62% and 72% of population access to electricity will be achieved by 2012 and 2014 respectively. The generation growth rate should be 10% to meet the government's projection on electricity. Furthermore, it is announced by the Government of Bangladesh for power sector vision in 2010 where total installed capacity would be 7000 MW, 8000 MW and 20,000 MW in the year of 2013, 2015 and 2021 respectively to make the free load shedding country. Per capita electricity consumption is 220 KWh in 2009 and it should be increased to 600 KWh by 2021 to meet the vision of the government (Bangladesh Power Development Board, 2010).

In 2009, about 43% of GDP is generated through the service sector. Ready-made garments, cotton textiles, pharmaceuticals, wood products, fertilizer, iron and steel are the main manufacturing industries in the industrial sector. The manufacturing industry contributed 17% (2009) of the GDP which is mainly dominated by ready-made garments. According to the

World Trade Organization Bangladesh is ranked as the 4th largest garments exporters in the world among the 10 garments supplier to the USA (WTO, 2010). Government of Bangladesh in 2010, projected that the contribution of agriculture sector will be 15% (21.70% in 2009) by 2021, industry sector will be 40% (29% in 2009) by 2021 and the service sector will be 45% (49.3% in 2009) in GDP by 2021(Planning Commission of Bangladesh, 2010).

Adverse Effect of Climate Change

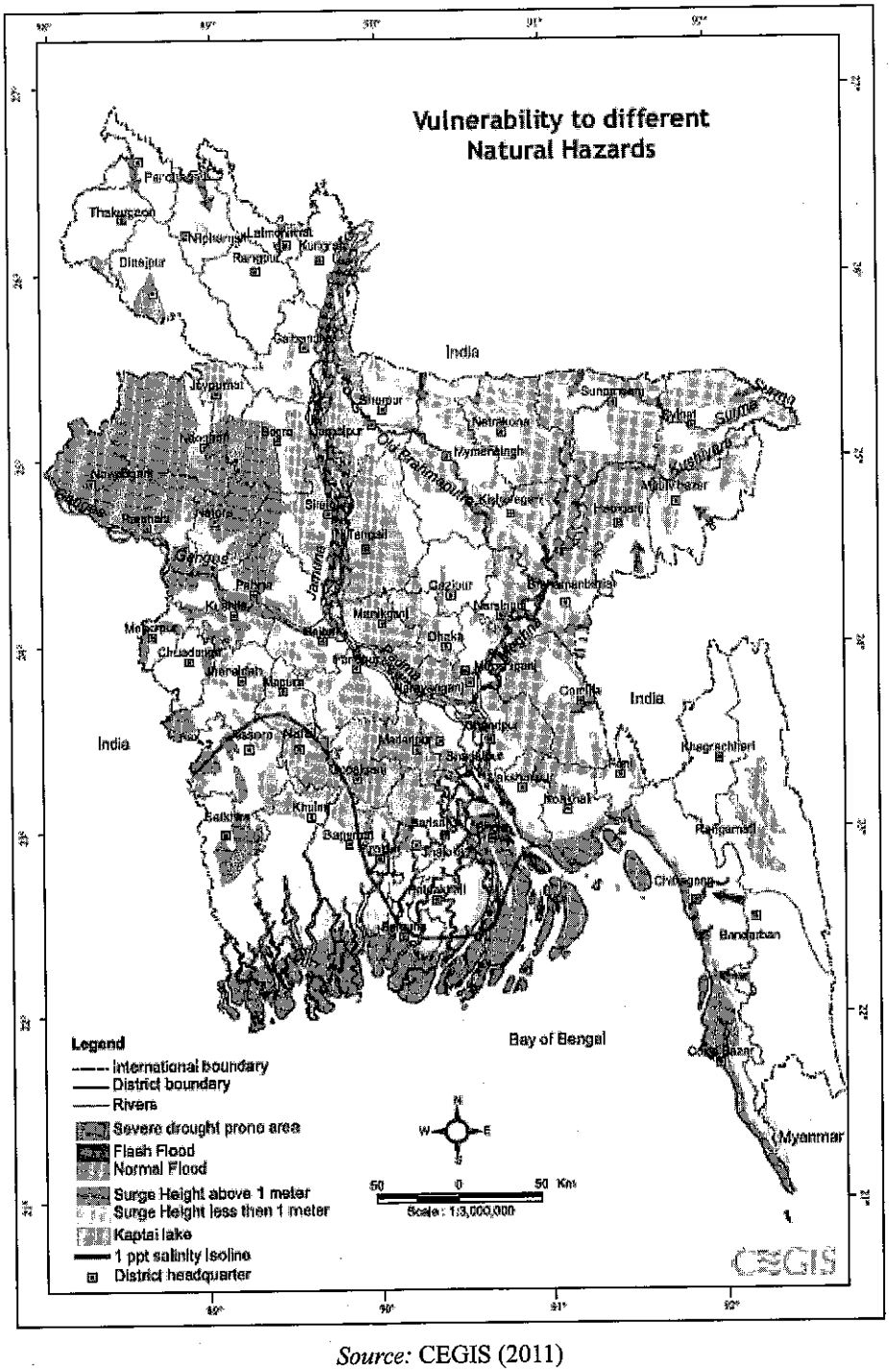
Due to the climate changes and geographical distribution, Bangladesh is one of the most susceptible countries to floods, tropical cyclones, storm surges, and droughts. The government and common people have inadequate ability to control the increasing impacts of global climate change and risks related to it. Over the last 35 years, Bangladesh has invested over $10 billion in preventing and minimizing the consequences of natural disasters (BCCSAP, 2009; MoEF, 2009). International Panel on Climate Change (IPCC) forecasted impact of climate change to Bangladesh as follows (IPCC, 2007):

- One meter rise in sea-level will inundate 20% of landmass by 2100.
- Changes in precipitation pattern will lose about 8% of rice and 32% of wheat production through enhancing flood polluted ground water, increase salinity in crop land resulting by 2050.
- Temperature increase by 1.4 to 5.8 degree Celsius will induce cyclone, drought etc.

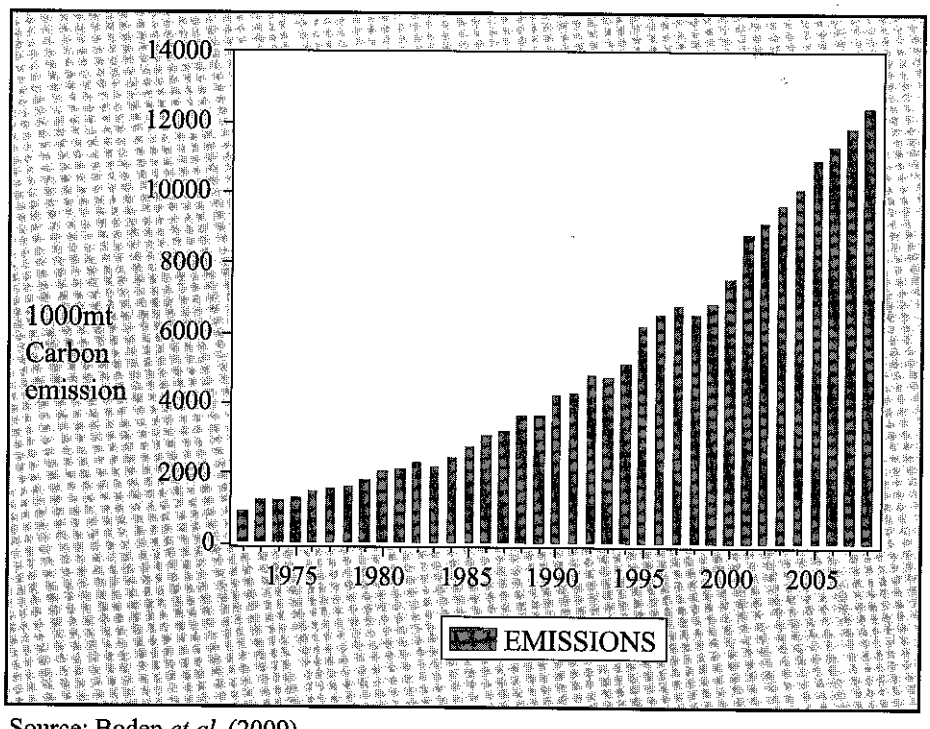
Trend of Carbon Emission in Bangladesh

Bangladesh is one of the lowest per capita carbon dioxide emission countries in the world. In 2005, the country emitted 142 millions tones of carbon dioxide excluding changes in land usage and forestry (CAIT, 2005). The largest source of carbon dioxide emissions is agriculture which is 66 percent; then the second source would be energy. About 8.7 percent of energy came from fuel combustion, 8 percent from electricity generation, 7.5 percent from manufacturing, and 2.7 percent from transport sector (Ellis *et al.*, 2009). The following figure shows the carbon emissions of Bangladesh during the year of 1972-2008.

The regions of the country vulnerable to different natural hazards are shown in the following map.



Source: CEGIS (2011)



Source: Boden *et al.* (2009)

Fig.-1: Carbon Emissions of Bangladesh (1972-2008). All emission estimates in thousand metric tons of carbon.

Bangladesh Plans One-Third Carbon Emission Cut by 2030

Despite being one of least contributors to global warming, Bangladesh promised to purchase a carbon efficient economy with the financial and technical support of the international community. As of now Bangladesh can reduce its total emission up to 14 to 15 percent but the total emission of Bangladesh is likely to increase nearly to 70 and to 150 million metric tons by 2015 and 2030 respectively. With the financial and technical support, Bangladesh plans to reduce at least one third of its total carbon emission by 2030. In the cancun agreement developing countries agreed to take nationally appropriate mitigation actions (NAMA) in the context of sustainable development, supported and enabled by technology and finance. The agreement also asked the developing countries for development of modalities and guidance for facilitation of support to NAMAs through a registry, measurement, reporting and verification (MRV) system (The daily Sun 2011).

Concept of Low Carbon Society for Bangladesh

Low carbon society (LCS) was firstly projected in the Japan-UK joint research project on "Sustainable low carbon society" and according to the project a low carbon society is required a sustainable development in all groups within the society, build equitable attempts for stabilizing greenhouse gases and avoid catastrophic climate change, utilize the sources and technologies in low carbon energy to increase energy utilizing efficiency and adopt the activities that are consistent with low levels of GHG emission (Japan-UK Project Report, 2008). A low carbon society should perform the actions related with sustainable development, reducing GHG emissions, get high energy efficiency and use low carbon energy, low carbon manufacturing technologies, and adopt low carbon living (Skea and Shuzo, 2008). In a nutshell low carbon society or low fossil fuel economy is a notion that refers to an economy which has a minimal output of greenhouse gas emissions (in particular, carbon dioxide) into the biosphere (LCS vision, 2010).

In developing country the concept is quite different where the concept can develop with a sustainable model which can meet up economic development and upgrading lifestyle. In a nutshell the same attention should be paid on environmental protection as well as other socio-economic security. A low carbon society should have following attributes (LSC Development towards 2025 in Bangladesh):

- Take actions that are compatible with the principle of sustainable development, ensuring that the development needs all groups within society are met.
- Make an equitable contribution towards the global effort to stabilize the atmospheric concentration of carbon dioxide and other greenhouse gases at a level that will avoid dangerous climate change, through deep cuts in global emission.
- Demonstrate a high level of energy efficiency and use low carbon energy sources and production technologies
- Adopt patterns of consumption and behaviour that are consistent with low levels of greenhouse gas emissions.

For economic development and carbon trade, Bangladesh requires a low carbon development pattern in order to make the effective medium and long run strategies.

National Policy and Strategies for Low Carbon Growth

Bangladesh is already affected by climate variability like flood, tropical cyclone, storm surges, and droughts which are becoming more and more frequent and severe in the upcoming years. Therefore, the government is paying its attention on the climate changes issue. The government has developed a warning system for floods, cyclones and storm surges, expanding community-based disaster preparedness, and developing research centers which detect climate resistant varieties of different kinds of crops (ADB, 2009).

In order to deal with the climate change and their impacts on the society and economy, the government of Bangladesh opened another branch called the National Adaptation Programme of Action (NAPA) in 2009 and the Bangladesh Climate Change Strategy Action Plan (BCCSAP) in 2010 (MoEF, 2009, 2010). The ministries and government departments provides input to NAPA and BCCSAP followed by UN guidelines. BCCSAP upheld the four building blocks of the UNFCCC Bali action named adaptation, mitigation, technology generation, and capacity building (Mallick and Rahman, 2010).

NAPA was set up by the MoEF, directed by the Project Steering Committee and members from other ministries, different departments and agencies including the Ministry of Finance and Planning. The NAPA identified vulnerable sectors, communities, geographical areas, households as well as individuals. It outlined 15 projects which included three projects about agriculture. It is based on promoting adaptation to costal crop agriculture, and promoting adaptation to coastal fisheries. Also, it focused on how to fight climate change impacts including raising general responsiveness and costal a forestation. So far, the NAPA reflected strong government contribution and diverse consultations.

The key aim of the BCCSAP is to promote climate resilient development and a low carbon economy in Bangladesh. In 2008, The BCCSAP was updated and revised. The 2009 version was prepared by a drafting and revision committee formed by the Ministerial Review Committee (MoEF, 2009). The BCCSAP is presented into two parts: first part was about illustrating background information about physical and climate contexts, core socio economic realities and policies in the country and the rationale behind the strategy. The second part provides a set of programmes based on six thematic pillars:

1. Food security, social protection and health;
2. Comprehensive disaster management;
3. Infrastructure development;
4. Research and knowledge management;
5. Mitigation and low carbon development; and
6. Capacity building and institutional strengthening.

The goal is to understand the need of the vulnerable poor people and help them to survive. The six themes encompass 37 programmmes to be implemented over the next 10 years. The BCCSAP is created a ten-year programme to cover the period from 2009 to 2018 to build the capacity and resilience of the country to meet the challenge of climate change. The strategy will comprise six pillars in the first five years, from 2009 to 2013 (Grabbert, 2010).

Recently, The Prime Minister of Bangladesh has called upon Belgian Prime Minister to increase additional European Union support to Bangladesh for the implementation of BCCSAP (BNN News).

Role of NGO and Civil Society

There has been a tremendous growth of non-government organizations (NGOs) participating in environmental issues. In Bangladesh, different kinds of NGO community are engaged with various social activities which might make people responsible to the environment. They are helping the government and vulnerable communities to mitigate the risks. The Bangladesh Centre for Advanced Studies (BCAS) is a private, non-profit research and policy making institution that was established in 1986. The organization is working to develop national capabilities in addressing resource management environment and development (RMED) issues by using existing intellectual, technology and manpower. Climate change adaptation and mitigation is a core area of the institution, and BCAS has achieved specialization in this area throughout the years by conducting research with sophisticated in house technology, making conscious decision, and designing advocacy campaigns (BCAS, 2009).

Some of the national NGOs (BRAC, RDRS, and GUK) and international development organizations (Care International, Action Aid, Oxfam GB and FAO) are trying to assimilate climate change adaptation into their development programmes (Mallik and Rahman, 2010). Recently, BRAC contributed to an interesting workshop named Statistical Downscaling for Developing Climate Change Scenarios which focused on the use and application such as robust statistical downscaling technique to support adaptation to local climate change impacts. That workshop suggested to build environment friendly designs and strategic planning for communities. (Star Campus, 2011).

Bangladesh financial institution estimates a budget for carbon trading to mitigate global warming. The Industrial and infrastructure development financial company limited (IIFDC), a non-banking financial institution, signed two emissions reduction purchase agreements (ERPA) for the first time with the help of World Bank and the Danish government to transfer 249,000 tones carbon dioxide from brick field. One study explores that, annually, total brick production of Bangladesh is estimated to be about 8.7 billion bricks with sale value of around US$450 million; which is one per cent of the country's total GDP. The calculations shows that the estimation is about 20 new energy efficient kilns which will be constructed to produce 300 million high quality bricks and expected to reduce emissions of carbon dioxide approximately 115,000 tons per year. The IIFDC estimated that the project will reduce an estimated 881,000 tons of carbon dioxide during 2010 to 2020 (Carbon Offsets Daily, 2009).

Kyoto Protocol and Bangladesh

Kyoto protocol was implemented at the first Conference of the Parties 3 (COP) on December 1997 in Kyoto, Japan. It was launch for signature on March 1998 and stopped up on March 1999. The goal of the Kyoto Protocol is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 2011). In 2001, Bangladesh signed and

ratified Kyoto Protocol. Bangladesh ratified the protocol positively because the country already facing huge risks of climate change (Hamada, 2006). According to the former UN, Bangladesh figures prominently on the world stage: it is expected to suffer, more than any other place on earth, the devastating impact of climate change" (Kofi Annan, 2001).

Recently, the COP 17 was held in Durban and ended in an anti climax. The world was expecting for a positive result, but the topic itself is so unpredictable that there is no immediate solution. Ministers of environment and negotiators from 195 countries had gathered to reach an understanding to diminish carbon emission. The main challenge of the Durban conference was to find an acceptable solution for countries to face this challenge in future. The Kyoto Protocol was about fighting global warming. Without renewing of Kyoto, Protocol the world would brace for more extreme weather conditions. The minister of Environment and Forests of Bangladesh told that "We are not happy but not frustrated either as it saved the Kyoto Protocol though Bangladesh expected much more from the conference. However, Japan, Russia, and Canada pulled themselves out of the process which is little unfortunate". (The Daily Star)

At the very last moment of COP 17, they signed a new legal framework called "The Durban Roadmap" which is seen as a major weapon to fight climate changes; for the first time, it will bring all major greenhouse-gas emitters under a single legal roof. If it is approved as scheduled in 2015, it will become operational by 2020.

Another hope is that, The Green Climate Fund created at the conference for helping vulnerable countries like Bangladesh, which is an achievement of the conference. Bangladesh has got $200 million as fast start funding out of $3 billion raised in the UNFCCC (The Daily Star report).

Factors Responsible for Carbon Emission

Table-1: Regression Analysis of Carbon Emission (1995-2008)

Variable	Coefficient	Standard Error	t-Statistic	Prob.
Consumption of Electricity	0.116254	0.047903	2.426839	0.0336
Population	166.5134	19.03754	8.746582	0.0000
Constant	-16787.47	2181.213	-7.696392	0.0000
R-squared	0.977037	-	-	-
Adjusted R-squared	0.972862	-	-	-
Log likelihood	-100.4947	-	-	-
Durbin-Watson stat	1.038684	-	-	-
S.D. dependent var.	2171.670	-	-	-
F-statistic	234.0187	-	-	-
F-Significant level	0.000000	-	-	-

Source: BBS (2010)
*Carbon emission= -16787.47+166.5134 *Population+0.116254 *Consumption of Electricity*
Dependent Variable: Carbon Emission

Form the above table one can say that, if the population increases 1 million then the carbon emission will increase 166.51 thousand metric tons and if the consumption of electricity increases 1MKW/H then the carbon emission will increase 0.116 thousand metric tons. Table-1 shows the consumption of electricity and population is highly significant (1 percent level) with carbon emission. The value of F is 234.019 and it indicates strongly significant. The R^2 value in the model was 0.977 that implies that independent variables can explain about 98 percent of the dependent variable (carbon emission).

Conclusion

Climate change has been called "a greatest market failure" (Stern *et al.*, 2006). That's why emission trading was formed to address this failure. This paper has analyzed the key factors responsible for carbon emission and mandatory realization for maintaining low carbon society development in Bangladesh. Also, the future of Kyoto Protocol should be concerned.

The major contribution of this paper is to show that Bangladesh is facing the challenges of the global carbon finance problem. It is required to promote adaptation to climate change. Carbon finance will help to find new ways to meet the climate change challenges. Furthermore, carbon finances market growing toward development to tackle these problems. The "learning by doing" approaches might help it to shape the international regulatory framework (World Bank, 2008).

In conclusion, it is mandatory to increase our academic research on carbon finance and low carbon economy to solve the country's problem in low carbon economy construction and know how to build new development system.

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Yield and Economic Return in Potato Minitubers Produced from Tissue Culture Derived Plantlets as Influenced byDate of Planting and Plant Spacing

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Abstract

An investigation was undertaken at the RDA Demonstration Farm, Bogra to find out the influence of date of planting and plant spacing on the yield of potato mini-tubers produced from tissue culture derived plantlets. There were three date of planting (P_1=10 November, P_2=25 November and P_3=10 December) and three plant spacing (S_1=10cm×25cm, S_2= 15cm×25cm and S_3=20cm×25 cm) of plantlets which in combination made nine treatments. The combined effects of the treatments were analyzed and found significant in most of the characters studied. The in-vitro plantlets planted on 10 November produced the tallest plants (24.16cm), fresh weight of haulm per hill (159.56 g), tuber weight per hill (162.78 g) and yield of tubers (33.79 t ha^{-1}). In vitro plantlets planted with closest spacing (10cm×25cm) produced maximum foliage coverage (95.89%), number of mini tubers per hill (15.38) and yield of tubers (32.57 t ha^{-1}). The highest yield (34.77 t ha^{-1}) was found in P_2S_1 which was statistically similar to P_1S_2 (34.66 t ha^{-1}) and P_1S_3 (32.46 t ha^{-1}). The highest benefit cost ratio (2.93) was found in P_2S_3 closely followed by P_1S_3 (2.80).

Introduction

Potato (*Solanum tuberosum*) is the most important tuber crop in the world as well as in Bangladesh. It belongs to the family Solanaceae. It ranks first among the vegetables in terms of area and production, and is the third largest food crop in Bangladesh next to rice and wheat. Potato contributed alone as much as 50% of the total annual vegetable production (Anonymous, 1998). Potato production in Bangladesh has been increased dramatically over the decades, yield rate has significantly increased. Total area under potato crop has been estimated at 10,63,204 acres (4,30,447 hectares) in the year 2010-2011. Average yield of potato was found at19.07 t ha^{-1} (2011-12) compared to 15 t ha^{-1} in 2007-08 (BBS, 2011). Consequently, the requirement of seed potatoes has increased noticeably in Bangladesh during the recent years, and there has been a remarkable shortage of quality seed potatoes in the country.

One of the most important reasons for the wide variation between potential and actual yields is extensive use of poor quality seed tubers by the potato growers of the country. Considering potato production is about 4.00 lakh hectares in the year 2007-08 and a seed rate of 1.5 t ha^{-1}, the requirement of seed potatoes in the same year was about 6.00 lakh tons for the country(Rabbani *et al.*, 2010). Out of the total quantity of seed potatoes used in the country in

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recent years, only about 6.00 % is of high quality (Supplied by BADC and Private Seed Companies). The rest 94% is farmers' seed potatoes, which are generally poor in quality.

Potato is usually planted in Bangladesh over early November to early December. However, temperature remains fairly high upto mid-October (Max. 32-30°C and Min. 27-24°C on average) which gradually comes down to about Max. 24°C and Min. 12°C on average by mid December. This cool period extends upto mid-February. The temperature rises sharply thereafter (Manalo, 1976). It is, therefore, important to see the effect of planting date on the growth and yield of potato mini-tuber production. The yield of potato like any other crop is under the control of the environmental factor. So, planting time is important factor for potato production. There had been a number of attempts in Bangladesh to find out the appropriate time for the planting of seed potato. Fortnightly plantings from October 25 to December 25, the highest yields were produced by the plants planting in November 10 and 25 (Ahmad and Quasem, 1967). The best yields were also obtained by the early plantings (Ahmad and Ahmad, 1974). The middle of November is the appropriate time of planting of potato in Bangladesh (Ahmad and Samad, 1976). There are some discrepancies in planting time of potato plantlets.

On the other hand, the plant spacing influences the yield of potato. Recent idea in vegetable growing industry is to obtain maximum yield per unit area through dense planting (Rashid, 1974). In general closer spacing up to certain limit increase the yield of tubers per unit area. Yield increased with a decrease in spacing from 20 to 25 cm in rows of 55 cm apart (Banerjee *et al.*, 1988). It was also reported that number of main stems per hill and yield of tubers per hill increased significantly with increase in plant spacing (Sultana and Siddique, 1991).

Application of tissue culture technology in the production of high quality seed potato is gradually increasing in Bangladesh both in the public and private sectors. Commercial exploitation of tissue culture technology started in different countries during 1960s (Chandra and Upadhya, 1998). In this system, disease-free potato plantlets are produced through tissue culture, and then the plantlets are grown in net-house for the production of mini-tubers. Subsequent multiplication of mini-tubers in open fields leads to production of different categories of seed potatoes.

It appears from available information that there is a need for improvement and standardization of practices for the production of potato mini-tubers using tissue culture derived plantlets. Research on plant spacing and date of planting would help standardizing the mini-tuber production practices and increasing the yield and quality of mini-tubers under net house condition. The researchers of TCRC are putting some efforts in this area (TCRC, 2009). While prioritizing research for horticultural crops, Siddique and Azad (2010) emphasized the need of developing easy and low cost techniques for production of high quality mini-tubers from tissue culture derived plantlets.

Objectives

Considering the above stated situation the present study was under taken with following objectives:

i) To determine the optimum plant spacing and date of planting for in vitro plantlets to produce maximum number of mini tuber; and

ii) To assess the economic returns in mini tuber production by using in vitro plantlets with different spacing's at different planting time.

Methodology

The present research would investigate the effects of different date of planting and plant spacing on the growth and yield of potato. This chapter consists of site selection, planting material collection and methods of experimentation.

Location

The experiment was conducted at the RDA Demonstration farm Bogra during the period from October 2011- March 2012.

Soil and Climate

The soil of the experimental field was clay loam in texture with pH 5.0-5.7 under the level Barind Tract of Agro-ecological zone 25. The plots were situated in a medium high land. The experimental area is a sub-tropical climatic zone and is characterized by heavy rainfall, high humidity and high temperatures during the Kharif-I season, and scanty rainfall, low humidity, low temperature and short day lengths during the Rabi season.

Planting Materials

The *in vitro* plantlets of potato variety 'Diamont' was used in the experiment. The plantlets were collected from Tissue Culture Laboratory, RDA, Bogra.

Design and Layout

The experiment having two factors was laid out in the Randomized Complete Block Design (RCBD) with three replications. First of all the entire experimental field was divided into three blocks, representing three replications. Each experimental plot size was 1.5 m×1.2 m.

Treatments of the Experiment

The experiment consisted of two factors (Planting time and Plant spacing).

Factor-A (Planting times):

i) P_1 =10 November
ii) P_2 =25 November
iii) P_3 =10 December

Factor-B (Plant Spacing):

i) S_1 = 10cm × 25cm
ii) S_2 = 15cm × 25cm
iii) S_3 = 20cm × 25 cm

Treatments: The experiment contained 9 treatment combinations (P_1S_1, P_1S_2, P_1S_3, P_2S_1, P_2S_2, P_2S_3, P_3S_1, P_3S_2 and P_3S_3).

Fertilizer Dose

Recommended doses of manures and fertilizers were applied in the experimental field (Hoque, 2001b).Well decomposed cow dung @ 30 t ha^{-1} was applied at the final land preparation. The entire doses of TSP (370 kg ha^{-1}), MP (370 kg ha^{-1}), Gypsum (160 kg ha^{-1}), $ZnSO_4$ (35 kg ha^{-1}) and Boric acid (25 kg ha^{-1}) were applied as pre-planting basal dose. The crop was top-dressed with urea (700 kg ha^{-1}) in two equal installments. The first and second installments of urea were applied at 45 and 60 days after transplanting respectively.

Land preparation

The land was opened on 25 October, 2011 at RDA, Bogra. The ploughing was followed by laddering to have a good tilth. During land preparation, stubbles were collected and removed from the field and the clods were broken. The surface of the land was leveled and finally irrigation and drainage channels were prepared around the plot. The corners of the plot were trimmed by spade.

Other Operations

The different intercultural operations such as weeding, mulching were done manually whenever necessary. Irrigation and plant protection measures were taken as and when necessary.

Results and Discussions

The results obtained from the experiment on the effect of date of planting and plant density of tissue culture raised plantlets for potato mini-tuber production were presented in this chapter. The results were discussed under the following heads:

Table-1: Interaction Effect of Date of Planting and Plant Spacing on Plant Height and Foliage Coverage at Different Days after Planting (DAP)

Treatment combination	Plant height (cm)at different DAP					Foliage coverage (%) at different DAP
	45	60	75	45	60	75
$P_1 S_1$	7.88	26.15	44.25	35.00	89.33	99.44
$P_1 S_2$	7.81	29.53	49.33	31.00	91.67	100.00
$P_1 S_3$	7.99	28.75	46.35	27.67	87.67	100.00
$P_2 S_1$	10.77	26.33	49.23	55.00	98.33	100.00
$P_2 S_2$	10.22	24.94	49.43	51.67	96.00	100.00
$P_2 S_3$	9.54	21.20	48.07	40.00	83.33	100.00
$P_3 S_1$	8.07	20.70	47.27	28.33	100.00	100.00
$P_3 S_2$	7.42	16.35	45.03	26.67	90.00	100.00
$P_3 S_3$	7.47	17.63	45.50	28.33	85.00	100.00
LSD at 0.05	-	-	-	-	6.77	-
LSD at 0.01	6.54	-	-	11.72	-	
Level of significance	**	**	NS	**	*	NS
CV%	8.92	11.66	6.57	13.66	6.35	11.68

* *Indicates significant at 5% levels of probability.*

***Indicates significant at 1% levels of probability.*

NS *Indicate non-significant*

Plant Height

The interaction between date of planting and plant spacing were found significant in case of plant height at 45 and 60 DAP which has been presented in (Table-1). During the period of plant growth maximum plant height (29.53cm) was recorded in the plantlets of P_1S_2 treatment followed by P_1S_3 (28.75cm) and P_2S_1 (26.33cm) while it was minimum (16.35cm) in P_3S_2 at 60 DAP. The variation in plant height may be due to the variation of nutrient, temperature and light as the consequence of different treatment combinations.

Foliage Coverage

The interaction effects of date of planting and plant spacing on foliage coverage was found significant at 45 and 60 DAP and it increased with progress in days after planting (Table-1). Foliage coverage varied ranging from 83.33% to 100% at 60 days after planting. The maximum foliage coverage (100%) was produced by the plantlets of P_3S_1 (early planting with closest spacing) followed by P_2S_1 (98.33%), P_2S_2 (96.00%) while it was minimum (83.33%) in P_2S_3 at 60 DAP.

Table- 2: Interaction Effect of Date of Planting and Plant Spacing on Vegetative Growth of Plants and Yield of Potato Mini-Tubers

Treatment combination (Date of planting × Spacing)	Number of stems/ hill	Fresh weight of haulm / hill (g)	Number of tubers/ hill	Weight of tubers/ hill (g)	Yield of tubers/ plot (kg)	Yield of tubers (t ha^{-1})
$P_1 S_1$	1.77	143.67	15.87	152.00	6.42	34.24
$P_1 S_2$	1.83	166.83	10.47	178.00	6.50	34.66
$P_1 S_3$	1.63	168.17	11.03	158.33	6.09	32.46
$P_2 S_1$	1.47	128.33	13.90	167.00	6.52	34.77
$P_2 S_2$	1.33	132.33	12.20	153.33	6.29	33.56
$P_2 S_3$	1.63	139.50	14.37	172.33	6.19	33.01
$P_3 S_1$	1.93	91.50	16.37	125.33	5.38	28.71
$P_3 S_2$	1.87	92.67	14.63	130.00	4.17	22.11
$P_3 S_3$	1.97	95.00	16.30	138.67	4.39	23.43
LSD at 0.05	0.35	-	-	-	-	-
LSD at 0.01	-	33.92	2.52	-	0.52	4.36
Level of significance	*	**	**	NS	**	**
CV%	11.68	11.06	10.47	15.26	5.98	5.94

** Indicates significant at 5% levels of probability.*
***Indicates significant at 1% levels of probability.*
NS Indicate non-significant

Number of Stems per Hill

The combined effect of date of planting and plant spacing were found significant on number of stems per hill (Table-2). The highest number of stems per hill (1.97) was produced from the treatment combination P_3S_3 (10 December planting with 20cm×25cm spacing). The lowest number of stem per hill (1.33) was produced with treatment combination P_2S_2 (25 November with 15cm×25cm spacing).

Fresh Weight of Haulm per Hill

Interaction between date of planting and plant spacing on fresh weight of haulm per hill was highly significant (Table-2). The maximum fresh weight of haulm per hill (168.83g) was obtained from P_1S_3. Minimum fresh weight of haulm per hill (91.50g) was recorded with the treatment combination of P_3S_1.

Number of Tubers per Hill

Interaction between date of planting and plant spacing on the number of tubers per hill was significant (Table-2). The maximum number of tubers per plant (16.37) was observed in the treatment P3S1 (10 December planting with 10cm×25cm) followed by P_3S_3 (16.30), P_1S_1 (15.87), P_3S_2 (14.63) and P_2S_3 (14.37) while the lowest number of tuber per plant (10.47) was found in P_1S_2. The number of tubers per plant was largely governed by the number of stems per plant. It was found that late planting plants with closest spacing P_3S_1 had more number of tubers per hill since it produced maximum number of stems/hill.

Weight of Tubers per Hill (g)

Interaction effect of planting date and spacing on weight of tubers/hill was found insignificant (Table- 2). Numerically it varied from 123.33 to 178.00g.

Yield of Tubers per Plot

The tuber yield per plot varied significantly due to influence of planting time and plant spacing (Table-2). The treatment combination P_2S_1 (25 November and 10cm×25cm spacing) produced maximum yield per plot (6.52 kg) closely followed by P_1S_2 (6.50 kg) while it was minimum (4.17 Kg) in P_3S_2 (10 December and 15cm×25cm).

Yield of Tubers (T Ha^{-1})

Significant variation in per hectare yield (t ha-1) was observed due to influence of planting time and plant spacing (Table-2). The highest per hectare yield (34.77 t) was produced by the plants of P_2S_1 (25 November and 10cm × 25cm) followed by P_1S_2 (34.66 t) and minimum (22.11 t) was in P_3S_2 (10 December and 15cm × 25cm).

Tuber Grade by Number (%)

There were no significant interaction effects of planting time and plant spacing on tuber grades by number except 'A' grade (Table-3). The maximum percentage (33.38 %) of 'A' grade mini tubers (<10mm) was found in P_3S_3 (10 December with 20cm×25cm spacing). The minimum percentage (10.48%) was found in P_1S_3 (10 November with 20cm×25cm spacing).

Table-3: Interaction Effects of Date of Planting and Plant Spacing on Different Grades of Mini-Tubers by Number (%)

Treatment combination	Tuber grade by number (%)			
	Grade-A (<10 mm)	Grade-B (11-20 mm)	Grade-C (21-30 mm)	Grade-D (>30 mm)
$P_1 S_1$	18.70	48.98	19.17	13.15
$P_1 S_2$	19.62	42.58	19.89	17.90
$P_1 S_3$	10.48	41.79	21.70	26.03
$P_2 S_1$	18.01	36.43	27.00	18.56
$P_2 S_2$	18.82	36.68	27.24	17.25
$P_2 S_3$	19.63	33.61	27.78	18.56
$P_3 S_1$	25.54	41.56	20.23	12.66
$P_3 S_2$	29.78	33.67	21.76	14.78
$P_3 S_3$	33.38	29.84	18.99	17.78
LSD at 0.05	6.44	-	-	-
Level of significance	*	NS	NS	NS
CV%	17.27	19.44	16.27	28.29

** Indicates significant at 5% levels of probability.*
NS Indicate non-significant.

Economic Analysis

In case of planting tissue cultured based plantlets involvement of labour cost was obvious. Total variable cost was highest (Tk. 81, 12,951) in mini-tuber production using *in vitro* plantlets of potato under P_1S_1, P_2S_1 and P_3S_1 treatments (Table-4). The high cost involvement was mainly due to high price of plantlets. Gross return was highest (Tk.1, 73, 85,000) when potato mini-tubers were produced from P_2S_1 treatment followed by P_1S_2 treatments (Tk.1, 73, 35,000) and P_1S_1 (Tk.1, 71, 20,000). Net return was highest (Tk.1, 25, 08,799) in P_2S_3 followed by P_1S_3 (Tk.1, 19, 63,799) and the lowest in P_3S_1 (Tk.69, 37,049). The highest BCR (2.93) was found in P_2S_3 closely followed by P_1S_3 (2.80) and it was minimum (0.85) in P_3S_1.

Table-4: Interaction Effects of Date of Planting and Plant Spacing on Different Grades of Mini-Tubers by Number (%)

Treatment	Total material cost ($Tk.ha^{-1}$)	Total non-material cost ($Tk.ha^{-1}$)	Total variable cost ($Tk.ha^{-1}$)	Yield ($t\ ha^{-1}$)	Gross returns ($Tk.ha^{-1}$)	Net Returns ($Tk.ha^{-1}$)	BCR
P_1S_1	7550451	562500	8112951	34.24	17120000	9007049	1.11
P_1S_2	5150451	428250	5578701	34.67	17335000	11756299	2.10
P_1S_3	3950451	315750	4266201	32.46	16230000	11963799	2.80
P_2S_1	7550451	562500	8112951	34.77	17385000	9272049	1.14
P_2S_2	5150451	428250	5578701	33.55	15370960	9792259	1.75
P_2S_3	3950451	315750	4266201	33.01	16775000	12508799	2.93
P_3S_1	7550451	562500	8112951	30.10	15050000	6937049	0.85
P_3S_2	5150451	428250	5578701	22.22	11110000	5531299	0.99
P_3S_3	3950451	315750	4266201	23.43	11715000	7448799	1.75

N.B. Sale price of potato mini-tuber = Tk. 500kg^{-1}

Conclusions

From the above discussions it is revealed the following conclusions:

- The plantlet of early planting performed best in respect of plant height, foliage coverage, number of stems per hill, fresh weight of haulm per hill, yield of tubers per hill, yield of tubers ($t\ ha^{-1}$).
- Foliage coverage, plant height, number of tubers per hill, yield of tubers per plot (kg) and yield of tubers ($t\ ha^{-1}$) were maximum in the plants grown with closest spacing while number of stems per hill, fresh weight of haulm per hill and weight of tubers per hill were highest with widest spacing.
- Early planting of plantlets with closest spacing performed better for foliage coverage, plant height and per hectare yield whereas late planting of plantlets with closest spacing performed inferior.
- The highest benefit cost ratio (2.93) was found in P_2S_3 closely followed by P_1S_3 (2.80) and it was minimum (0.85) in P_3S_2.

Recommendations

Planting of *in vitro* Plantlets at 10 and 25 November with 20cm x 25cm spacing is recommended to produce mini-tubers as profitable starting material for seed potato production.

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Comparative Study of RDA Developed Low Cost Water Supply Model with Subsidized System

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Abstract

This study makes a comparison of RDA-developed low cost DTW model (including installation cost, cost of water supply and gained return) of sub-project area with that of a subsidized water supply system under Government management. The study was conducted in Sherpur pourashava under Bogra district where RDA-developed low cost DTW model was implemented with subsidized water supply system provided in under Government management. Installation cost of DTW was higher (Tk. 10.00 lakh) than RDA-model in Sherpur Pourashava (Tk. 5.82 lakh) and also capacity of DTW was one-third times less than Bogra Pourashava (100 m^3/h) than RDA-model in Sherpur Pourashava (150 m^3/h).Expenditure for domestic water supply and irrigation purposes in Sherpur Pourashava was Tk. 4.23 lakh where expenditure for electricity bill, salary for water charge collector, operator salary, operation and maintenance were 76%, 14%, 3% and 7% respectively. On the other hand, yearly gross expenditure in was Tk. 47.16 lakh where manpower salary was 23% and electricity bill, O&M and others costs were 77% respectively. Yearly gross income in Sherpur Pourashava through collection of water charge and irrigation was TK 7.39 lakh, where domestic water supply was 94% and irrigation 6%. Yearly gross income and expenditure were Tk. 43.58 lakh and Tk. 47.16 lakh respectively. As a result net profit in Sherpur Pourashava was Tk. 3.16 lakh and net loss was Tk. 3.58 lakh in Bogra Pourashava. Here, conclusion drawn that Government management project was a subsidized system and private operation system (Sherpur Pourashava) was a profitable project. So, RDA Developed low cost water supply model in Sherpur Pourashava could be implemented throughout the country.

Introduction

Water is essential to all living organisms for their survival and growth on the earth. Safe, adequate and accessible supplies of water combined with proper sanitation are the basic needs and essential components of primary health care. In Bangladesh, hand tube well (HTW) is mostly used for abstracting groundwater for drinking purposes. The hand tube wells abstract groundwater usually from shallow aquifer and there is risk of biological and chemical contamination and water quality deterioration in many places. It has been reported that about 35 million people are affected by arsenic contaminated groundwater through drinking andother unknown ways (Khan and Ahmad, 1997; Khan *et.al,* 1997). In recent years, Rural

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Development Academy (RDA) developed low-cost deep tube well (DTW) technology for multipurpose uses like safe drinking water supply, domestic uses, irrigation, aquaculture etc. that has been adopted by many government and non-government organizations.

Until the end of 2012, Rural Development Academy (RDA), Bogra has installed about 300 low-cost deep tube wells with and without water filtration plants in various GO's, NGO's and association (*Sammity*) or individual of throughout the country. Matin *et. al.* (2001) examined the safe drinking water supply system introduced at rural level for multipurpose uses through RDA developed low cost technology and it was observed that overall performance of DTW was good and accepted by stakeholder. Matin *et. al.* (2000) also had conducted a performance evaluation and showed that the RDA-developed DTW technology has adopted by many GO and NGOs for domest–cum-irrigation water supplies at different locations within the country. Such a DTW was also getting popular among the stakeholders for their small scale multipurpose uses.

It is, therefore, necessary to undertake a study in order to judge the comparison of the RDA installed low cost DTW model in terms of quality drinking water supply, cost, durability, operation and maintenance and other technical aspects of the system with subsidized water supply system by the Government management.

The present study was under taken in Sherpur Pourashava where RDA developed low cost DTW model was implemented. Beside this, the implementing agency of that sub-project was Sonajhora Private Operator Water Supply Group (SPOWSG).This sub-project has been compared with another water supply project implemented by the Bogra Pourashava authority under Government management.

Objectives

Therefore, the main objective of the study was to compare the safe water supply system by transferring RDA-developed low cost DTW model under a sub-project area with subsidized water supply system by the Government management.
The specific objectives were:

i) To assess the investment cost of RDA- invented low-cost deep tube well model with its components and subsidized system ;

ii) To calculate the cost of water supplying charge both at RDA paid water supply model and subsidized system under Government management; and

iii) To assess cost benefit analysis of both the system.

Methodology

Study Design

This was a cost benefit analytical study between RDA-developed paid water supply systems with subsidized under Government management. The study used both quantitative and qualitative investigation techniques to appropriate in designing the approaches which are narrated below:

Quantitative Investigation

It was conducted quantitative survey among the target respondents taking statistically appropriate sample size. The task also includes preparation/finalization and pre-testing of questionnaire, identify sample size, train data collectors, data collection and ensuring quality control, data editing and processing and preparation of report. In addition, secondary information related to investment cost, income and benefit was collected from both the RDA-developed sub-project area and subsidized under government management.

Qualitative Investigation

It was helped to find out qualitative issues (i.e. behavioral and attitudinal insights, suitable IGAs, quality of services, priority of interventions etc.). It also facilitated to design the quantitative data collection tools. Qualitative investigation had been done using techniques such as:

- Focus Group Discussion (FGD)
- Suitable Participatory tools such as, Stakeholder analysis, Casual diagram, Preference ranking etc.
- Case study (Best Practice).

Study Area

The study was conducted in Sherpur pourashava under Bogra district where RDA invented low cost DTW model implemented. It is located about five kilometers south from RDA besides Dhaka to Bogra highway.

Another Government management system was selected in Bogra Pourashava under Bogra district. It is about 16 kilometers north from RDA beside Dhaka to Bogra highway. The geographic dispersion of the sub-projects location in the study area is illustrated in the following table-1.

Table-1: Location of the Study Area

Sl. No.	Name of Project	Name of Owner	Upazila/Pourashava	District
1.	Sonajora Water Supply Group	Private (Hazi Md. Ishaq)	Sherpur Pourashava	Bogra
2.	Water Supply in Bogra Pourashava	Government Management (Pourashava Authority)	Bogra Pourashava	Bogra

Data Collection

For data collection, a number of standard techniques were used such as review of relevant papers and documents, focus group discussion, stakeholder analysis and case study. The study also describes on our own work experiences and direct observation with the beneficiaries under Water Users Groups (WUG). A separate procedure for each data collection methods was pursued with different categories of respondents. Both primary and secondary sources of data were collected in this study.

Quality Control

There was a solitary member of the study. There searcher (Agricultural Engineer) was directly concerned in data collection. All type of contradiction was analyzed and reviewed under close supervision by the principal researcher.

Data Analysis

After completion of collecting data, these were compiled, tabulated and analyzed according to the objectives of the study. Data were processed and entered into computer using MS Excel (Microsoft Excel) and analyzed as per objectives by tabular and graphical methods.

Scope and Limitations

The study has been focused on comparison to investment cost, income and profit of water supply under both RDA-developed low cost models with subsidized system. For validity and possible implications, it is often assessed and compared by actual field experience and also secondary information.

There were some limitations like time, fund and other relevant accessories. Time span was very short for data collection, about two months. As a result, this study could not take into the views of the more other relevant stakeholders, users, Non-government officials and other civil societies.

Results and Discussions

Comparison of Investment Cost in the Both Project

Comparison of investment cost in both the project such as production DTW, overhead tank and domestic water supply network are shown by following bar chat (Figure-1). Cost of production DTWs in Bogra Pourashava was Tk. 10.00 lakh having discharge capacity 100 m^3/h each. There were 17 DTWs installed in Bogra Pourashava including 14 were under operation, 01 was under commissioning and rest of 02 were inoperative. Cost of overhead tank in Bogra Pourashava varies from Tk. 60.00 lakh to 100.00 lakh having capacity from 6.75 lakh litre to 10 lakh litre. Domestic water supply network in Bogra Pourashava was Tk. 2450.00 lakh for 488720 ft various diameters of MS/Ductile Insolate (DI)/ Asbestos Concrete (AC)/uPVC etc.

RDA developed low cost DTWs was Tk. 5.82 lakh having capacity 150 m^3/h. Besides these, there was only 01DTW installed in Sherpur Pourashva and installation cost of those DTWs was lower than Bogra Pourashava. The capacity of DTWs was one-third times less in Government management than RDA-model in Sherpur Pourashava.Cost of domestic water supply network in Sherpur Pourashava was Tk. 6.26 lakh for 5540 ft various diameters of uPVC pipelines including 1540 ft bio-gas connection for household purpose. In addition, NGO has been installed 15000 ft various diameters of uPVC pipeline network by their own fund that cost could beraised Tk. 21.00 lakh.

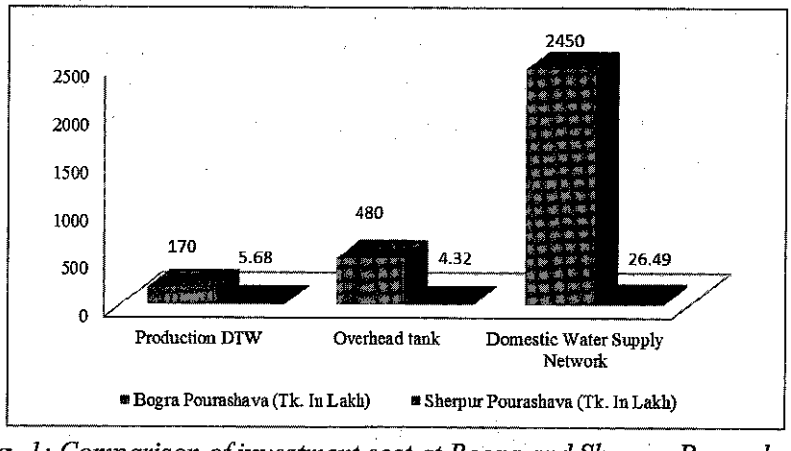

Fig.-1: Comparison of investment cost at Bogra and Sherpur Pourashava

Expenditure through Domestic Water Supply and Irrigation in Sherpur Pourashava

Expenditure for imbursement of electricity bill, salary for water charge collector, Operation and Maintenance (O&M) etc. throughout domestic water supply and irrigation purposes were Tk. 4.23 lakh. Among the yearly expenditure in Sherpur Pourashava for electricity bill, salary for water charge collector, operator salary, operation and maintenance were76%, 14%, 3% and 7% respectively (Figure-2). The highest cost remains 76% in electricity bill and lowest cost involves 3% in operator salary for three months of irrigation purposes.

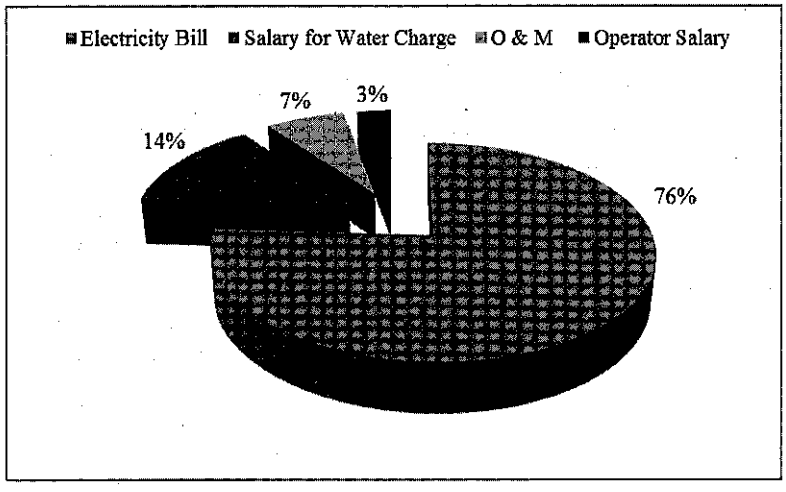

Fig.-2: Yearly expenditure in Sherpur Pourashava

Expenditures through Domestic Water Supply in Bogra Pourashava

Expenditures allied to pay salary for manpower, electricity bill, operation and maintenance cost etc. for supplying water in Bogra Pourashava. Total numbers of 28 people was appointed for management of water supply in Bogra Pourashava. There were various categories of manpower worked in such as water super, driver, water charge collector and staffs for peon, guard and sweeper. Yearly gross expenditure for manpower salary was Tk. 16.56 lakh. Yearly electricity bill and O&M cost of Bogra Pourashava was 30.60 lakh. Therefore yearly gross expenditure in Bogra Pourashava was Tk. 47.16 lakh where manpower salary was 23%and electricity bill, O&M and others costs was 77% (Figure-3).

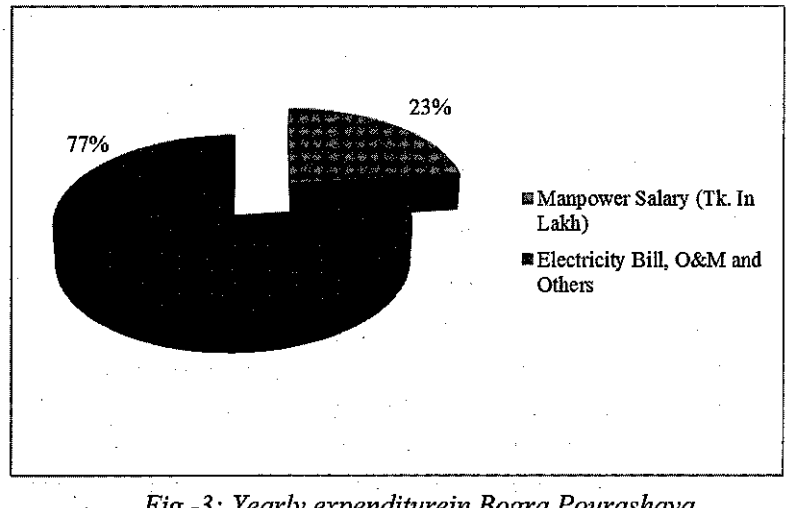

Fig.-3: Yearly expenditurein Bogra Pourashava

Return through Domestic Water Supply and Irrigation in Sherpur Pourashava

Connections for total 580 households were in Sherpur Pourashava for supplying safe drinking water in the beneficiaries yet studies period. The project owner collected Tk. 100 per household per month as input cost for supply of water. Here referred that project ownership has got this sub-project from RDA for the 10% advance down payment of Tk. 2.20 lakh out of total investment cost Tk.22.00 lakh. Rest of Tk. 19.80 lakh would be paid by the ownership after rest 9 years of the projection period without interest by made a MoU between RDA and the project ownership for this purpose. After 10 years when project ownership would be furnished total investment cost, the project would be handover for the concern authority as an ownership. Total yearly income from domestic water supply was Tk. 6.90 lakh and command area was 12 acres for irrigation under this project and early return was Tk. 0.43 lakh for supplying water in irrigation. Therefore yearly gross income through collection of water charge and irrigation was 7.39 lakh. The maximum income had come from domestic water supply 94% and rests 6% was from water supply in irrigation field for crop production (Figure-4).

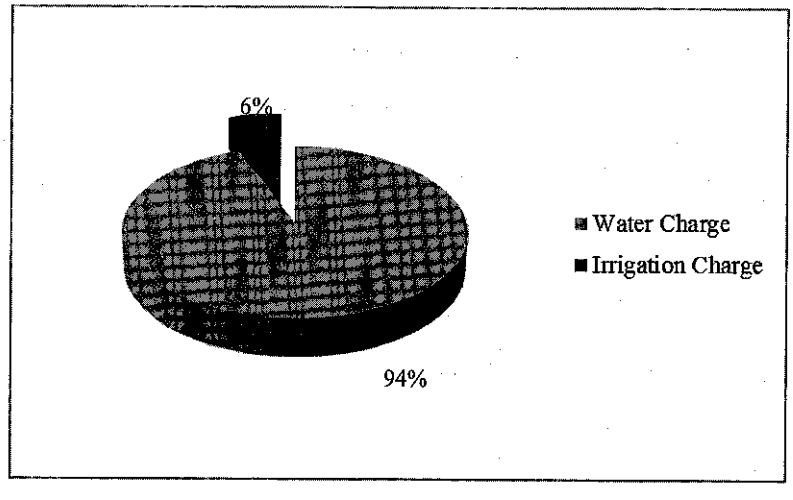

Fig.-4: Yearly income in Sherpur Pourashava

Return through Domestic Water Supply in Bogra Pourashava

Return comes from monthly water charge and down payment mainly. There are three types of pipe line connections in Bogra Pourashava like residential, commercial and hot line for supplying water. Hot line connection means water supplied from overhead tank to users directly. In Bogra Pourashava, gross income for water supply from residential, commercial and hot line connections wereTk.19.44 lakh (45%), Tk. 23.09 lakh (53%) and Tk. 1.05 lakh (2%) respectively (Figure-5). The peak income comes 53% from commercial purposes of water use and lowest income 2% from hot line connection.

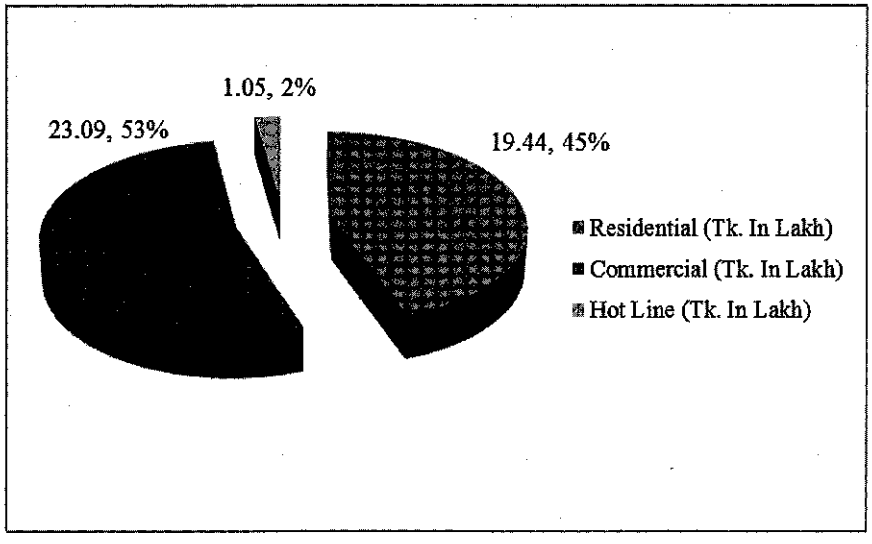

Fig.-5: Yearly gross income from water supply in Bogra Pourashava

Comparison of Yearly Cost Benefit Analysis in both Projects

Yearly gross income, expenditure and net profit in Sherpur Pourashava were Tk. 7.39 lakh, Tk. 4.23 lakh and Tk. 3.16 lakh respectively. Yearly gross income, expenditure and net loss in were Tk. 43.58 lakh, Tk. 47.16 lakh and Tk. 3.58 lakh respectively. Therefore, water supply in is a loss project (Figure 6).

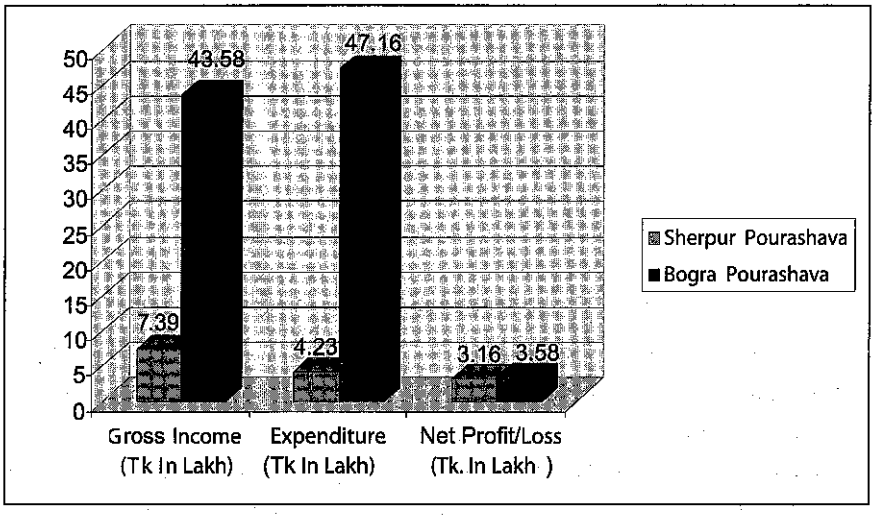

Fig.-6: Comparison of gross income, expenditure and net profit/loss between Sherpur and Bogra Pourashava

Conclusions and Recommendations

A number of inferences can be drawn from this action research. First, the findings of the study, RDA-developed low cost water supply as a "Model" could be piloted in a number of locations on a systematic method and then replicated throughout the country if found suitable. Because the results of this action research suggests the Model has to be cost effective and demand-driven. This is the case where ground water was extracted from a suitable aquifer level. Second, the study has provided new information in respect of different way of safe water for drinking purpose, developed a device of water charge payment methodology for the clients (the users/villagers). Third, findings of this comparative study may guide other researchers and managers working in expansion or enlargement similar projects.

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Understanding Disaster Impacts through a Gendered Lens: A Study on the *Char*-dwellers of the Jamuna River in Bangladesh

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Abstract

The study examines gender-specific disaster impacts on the char-dwellers of the Jamuna River in Bangladesh. Many studies show how local people particularly from the developing world are victimised by disasters. The study area is Char Sthal Noahata, a char (river island), situated in Chauhali upazila (sub-district) in Sirajgonj district, which is highly prone to recurrent floods and river bank erosions. The study applies qualitative methods for data collection through using different participatory rural appraisal (PRA) tools and focus group discussion (FGD). The findings of the study show that how both men and women are affected by floods primarily the flood of 2007. The study explores some gender-specific impacts. Unavailability of work, cattle rearing problems, scarcity of food and communication problems are the major vulnerabilities of men to floods, mainly related to their livelihoods. On the other hand, women are vulnerable to availability of food, drinking water and clothing during floods as these issues are related to their cultural driven domestic responsibilities and their privacy. Finally, the study recommends gender-specific actions may reduce disaster damages and losses in terms of decreasing their vulnerability and increasing capacity.

Introduction

The world is vulnerable to floods, especially since last century when lots of severe floods occurred in North America, Europe and Australia (Wisner *et al.* 2004). But the poor people of the developing world are more vulnerable to disasters (Brammer, 2004; Wisner *et al.*, 2004; Collins, 2009; Intergovernmental Panel on Climate Change, 2012). Bangladesh is a flood prone country because of its geographical location. Floods in Bangladesh occurred after a regular interval of about 10-15 years such as 1954, 1955, 1970, 1971, 1987, 1988, 1998, 2004 and 2007, though floods of 1987, 1988 and 1998 have had severe effects on human life and the economic life of the country (Brammer, 2004; Government of Bangladesh, Department of Disaster Management, 2013).

The Jamuna river basin is one of the multi-disasters prone areas of Bangladesh. In wet season the area is affected by floods and river bank erosion and in dry season drought often affects the area (Baqee, 1998). Approximately around one million people living on island chars are surrounded by water for the majority of the year. The people, who live in the *chars* of the

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Jamuna, are one of the most vulnerable communities in the world. Erosion and annual flooding forced thousands of households to move each year, often shifting between five and seven times in a single generation (Haque and Zaman, 1989; Baqee, 1998; Brammer, 2004). The vast majority of char households are not covered by standard government services including health, education and police protection (*Chars* Livelihoods Programme, 2013). Thus, women of the chars are more vulnerable to disaster (Schmuck-Widmann, 1996; Nasreen, 1999).

A number of studies have explored flood impacts on local community and how they cope with those events. Most of the studies were based on quantitative approach whereas few of them followed qualitative methods including focus group discussions (FGD) and in-depth interviews. Nonetheless, there are many Participatory Rural Appraisal (PRA) tools that can be utilized for transferring the local people's views into pictorial presentations. Few have looked into the issue focusing on gender context (Hossain *et al.*, 1987; Aman, 1999; Nasreen, 1999). A very few studies directly concentrated on this issue that gender-specific flood impacts on the char-dwellers of Bangladesh by using participatory qualitative approach. Thus, it is very important to make understanding disaster impacts on women in the *char* areas.

Objectives of the Study

The main objective of the present study is to provide an overview of the state of flood impacts on the *char*-dwellers in the Jamuna river basin with an emphasis on identification of gender-disaggregated impacts. Therefore, the study explores the status of particular factors manipulated by floods such as work availability, mobility, daily routine, diseases and availability of medical facilities.

Research Methods

The study was primarily conducted through qualitative approach. The respondents of the study were the *char*-dwellers including the poor and the extreme poor categories as well as male-headed and female-headed households. Primarily the methods of data collection were different PRA tools including Focus Group Discussion (FGD). Table-1 shows how the respondents of the study identified and described their flood impacts by using different PRA tools.

Table-1: Research Methods Used

Objectives	Methods	Description
Identifying major problem faced by the respondents during and after floods	Problem priority and FGD	• Identified major problems • Scored them • Finally ranked them according to scoring
Exploring availability of work	Seasonal calendar	• Identified work availability by (Bengali) month • Used histogram for both 'normal' and 'flood-hit' year
Mapping mobility crisis	FGD	• Identified major destinations in their daily life and why they go those places • Explored how floods effect on their mobility
Drawing and comparing their daily routine during normal and flood time	Pie diagram	• Divided their daily work in terms of Islamic prayer time[2] • Used two pie diagrams for drawing and comparing their daily routine during normal and flood time
Identifying diseases and availability of medical facilities during floods	FGD	• Identified diseases increased due to floods • Explored medical facilities during flood period

[2] *It is observed that the daily routine of char-dwellers is managed by prayer time. They decide which task(s) they do before or after a specific prayer time.*

The respondents of the study were selected by their individual interest to participate in several sessions. However, the research carefully observed and stratified individual lifestyle and livelihood, and how they were victimized by floods particularly in 2007.

Study Area

The study area is *Char* Sthal Noahata in Chauhali *upazila* under the Sirajgonj district (Figure-1). The topography of the char is almost homogenous – flat low-lying land extremely prone to recurrent floods and river bank erosions. It is divided into two parts known as *Uttar* (north) Noahata and *Dakshin* (south) Noahata separated by a natural canal especially in the wet season. The population and household of *Dakshin* Noahata and *Uttar* Noahata are 1,413 and 246 respectively, where the poor and extreme poor make-up 67% of the population. Though the study was conducted at the south part of the *char*, the name of the study area is referred as '*Char* Sthal Noahata' throughout the paper.

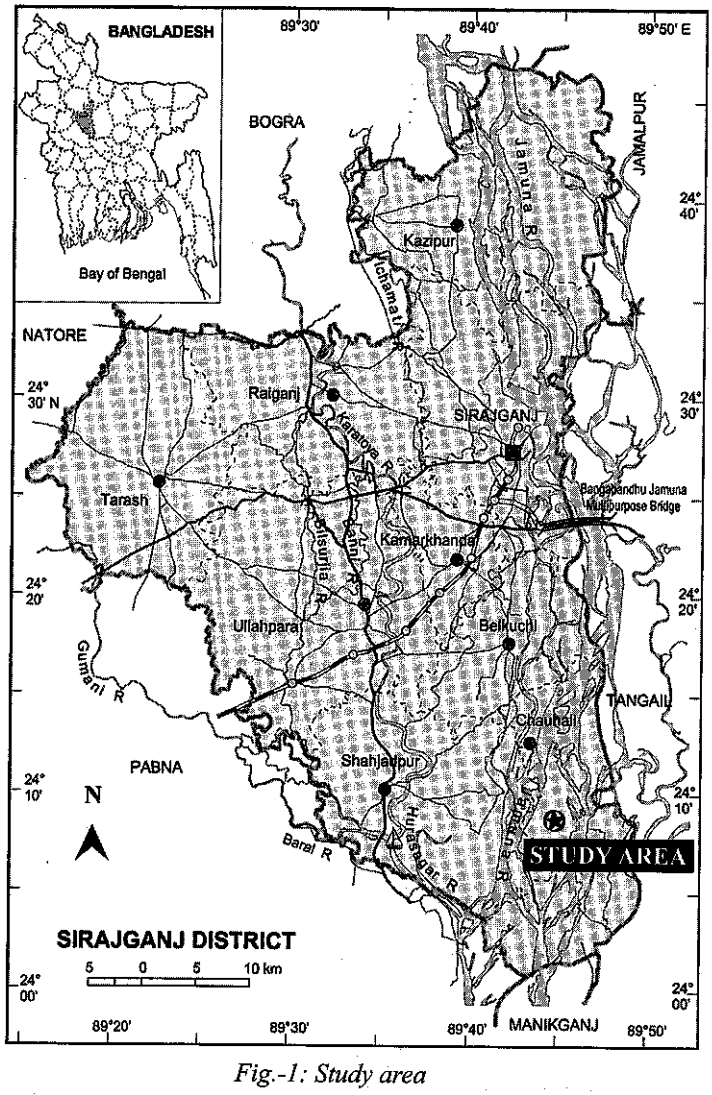

Fig.-1: Study area

Results and Discussions

Flood Impacts on the *Char*-Dwellers

The respondents of the study area explain how they were affected by the 2007 flood. These impacts on male and female groups are varied due to their different livelihood strategies and division of labour. Men identify lack of work as the main problem due to floods and scored 10 out of 10 (Table-2). Unavailability of food and livestock rearing are jointly ranked second (scored 9) followed by mobility problems and lack of sanitary latrines (scored 8). Housing problem is also ranked fourth (scored 7) and lack of health facilities is fifth (scored 6). The male group scored five for lack of drinking water and ranked the lowest.

Table-2: Gender-specific Flood Impacts

Major flood impacts	Male		Female		Total	
	Score	Rank	Score	Rank	Score	Rank
Unavailability of food	9	2	10	1	19	1
Problem of cattle rearing	9	2	6	4	15	2
Scarcity of drinking water	5	6	8	2	13	3
Defecation problem	8	3	5	5	13	3
Communication problem	8	3	4	6	12	4
Lack of work	10	1	-	-	10	5
Lack of clothing	-	-	7	3	7	6
Homestead erosion	7	4	-	-	7	6
Problem of diseases	-	-	6	4	6	7
Lack of medical facility	6	5	-	-	6	7
Cooking problem	-	-	5	5	5	8
Showering problem	-	-	5	5	5	8

On the other hand, women rank lack of food (scored 10) as the main problem due to flood (Table-2). Lack of drinking water is identified as a vital issue by them (scored 8). Clothing is also identified as another major factor because of their personal privacy (scored 7). They cannot clean, dry and change their cloth when it is necessary. Problems related to livestock rearing and increasing diseases jointly ranked fourth (scored 6). Lack of sanitary latrine and showering problems are ranked fifth (scored 5) whereas mobility problem is selected as the least important problem in the table (scored 4).

However, we observe from the Table-2 that vulnerabilities vary between men and women according to their responsibilities and demands. For example, men rank work unavailability on top because they are responsible for earning money. On the other hand, women choose lack of food and drinking water because they are liable to manage and cook food, and further collect and preserve water for drinking and other purposes. Furthermore, though lack of sanitary latrine is a common problem men scored more compared to women. Availability of dry cloth (scored 7), diseases (scored 6) and showering or bathing (scored 5) are also common problems of women during flood which are related to their personal hygiene and privacy. Alternatively, men score 8 against mobility problem as they cannot move to their different destinations during flood. Though both men and women are affected by floods, women face more problems compared to men.

After considering the above facts, it is important to understand how floods create problems in the daily life of the *char* dwellers. These factors include work availability, mobility, daily routine, diseases and availability of medical facilities affected the daily life of *char* Dwellers irrespective of gender.

Availability of Work

Unavailability of work is the main problem of the *char*-dwellers during flood and men prioritised it on the top of their list. It happens during the months of July to September (*Ashar* to *Ashwin*). In these months usually flood occurs on a regular basis. So, the head of most households try to stay at their home though they have no work in and around the *char*. This situation is called *monga* happened during these months at Sthal Noahata. However, the main livelihood options for the men of the study village include wage work in crop fields and handlooms, earth digging, rickshaw-pulling and small business. Figure-2 demonstrates how flood affects their normal work.

The men get work from November to July (*Agrahayan* to *Ashar*) in a normal flood year. From April to June (*Boishakh* to *Ashar*), they work in crop field for *boro* rice harvesting, and *aus* and *aman* rice planting. They then harvest *aman* rice in the months of November and December. Further, they harvest some winter crops in February and March. Earth-digging is another option for men especially in the winter season. Moreover, they can work handlooms over the year except during the rainy season because most of the handlooms are partially damaged by rains.

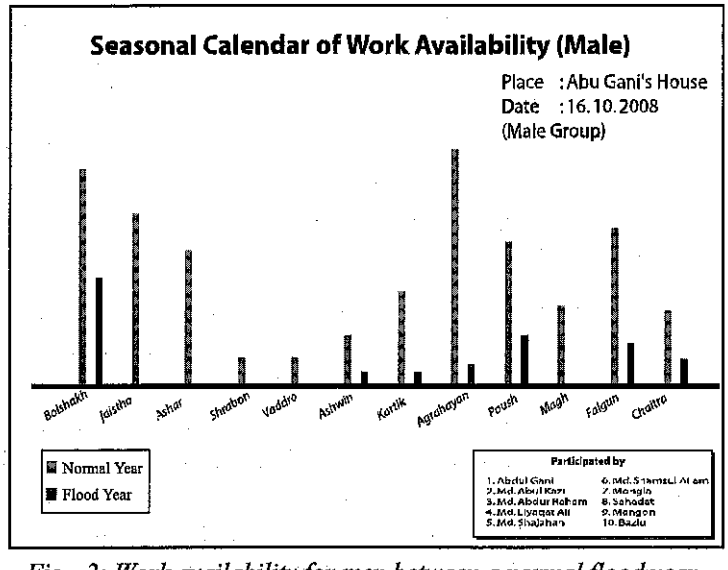

Fig.- 2: Work availability for men between a normal flood year and a severe flood year

In contrast, the men frequently lose their jobs during and after flood. Because abnormal floods damage existing crops in fields and prevent farmers from sowing winter crops as well. So, they can work only in crop fields in April–May in a severe flood year. They have faced problems getting work from July to December. However, they harvest winter crops from January to March. Besides, handloom workers cannot work because either handlooms are damaged by floodwater or loom owners get few orders for delivery.

On the other hand, it seems women are mainly accountable for their domestic tasks; however, many of them work outside of the home. Figure-3 illustrates how flood effects the paid employment of women.

The women of Sthal Noahata get work from April to June and November–December in a normal flood year. However, from April to June (*Boishakh* to *Ashar*), they work at earth-digging and in the agricultural fields. November and December are the busiest months for women. They are mainly involved in post-harvest activities like rice threshing, boiling and drying. They also work in well-off houses doing domestic chores including repairing rooms, painting houses by mud, etc. Furthermore, they work in February–March (*Magh* to *Chaitra*) harvesting winter crops. But during the rest of the year, women usually cannot work outside of their homes as because of there is little suitable work in agricultural fields, especially land preparing and seed sowing which are mainly reserved for men.

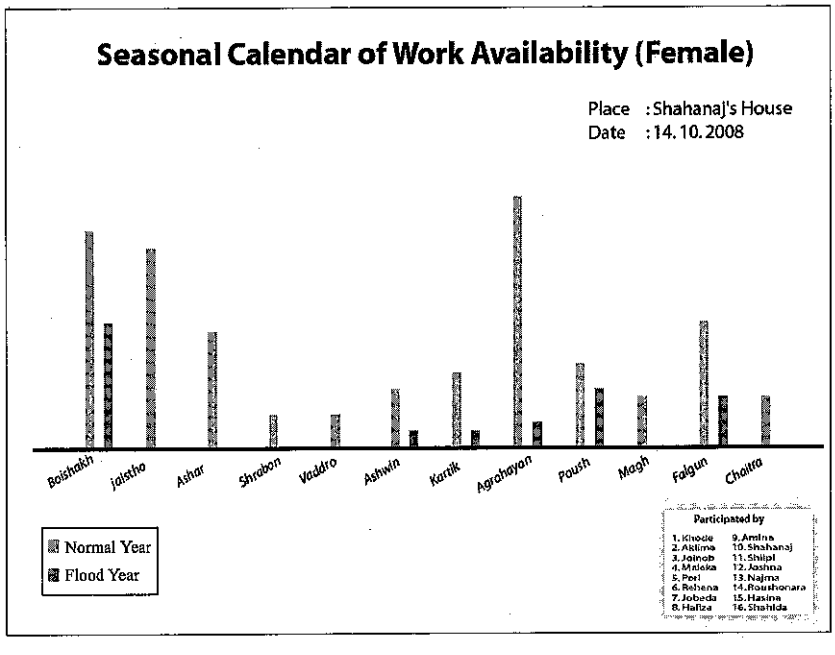

Fig. - 3: Work availability for women between a normal flood year and a severe flood year

On the other hand, it can be assumed that there will not be any paid work for women during flood. They claim that there is no paid work for women not only during flood but also after flood in a severe flood year. Besides, well-off families are also at risk during the season. So they do not hire women for domestic works. Women can work only April–May in a severe flood year. In this time, they can get work in agricultural fields by preparing and weeding along with men though they are often underpaid. Nonetheless, in the month of February and March they are sometimes involved in sowing winter crops after the floodwater has gone down.

Figures-2 and 3 indicate that the trend of work availability for both men and women is roughly the same and both face problems getting enough work during flood. However, women are often deprived more in terms of getting a job and they are underpaid particularly during and after a severe flood.

Mobility Crisis

To cope in the *char's* exigent situation, *char*-dwellers adapted and follow different livelihood strategies. Most of them have to move to different places round the year to cope with severe erosion and flooding. However, their mobility is affected by floods. The pattern mobility is quite different between men and women, and verily it is changed during flood. Here, mobility means where the *char*-dwellers usually move for meeting up their daily needs rather than migrate seasonally or for medical treatment purposes at long distance for a long time. Men usually go to different places for their jobs and sometimes for social gatherings. Table-3 describes where and why they go.

Table- 3: Destinations of Men and Reasons for Mobility

Places	Reasons
Anayetpur, Sirajgonj – a local business centre	It is the highest frequented place for men. They usually go there for business, jobs and daily needs.
Koijuri, Sirajgonj – a famous local bazaar	It is the second highest frequented place for men. Handloom workers often go there for work and others go for small business and shopping.
Sirajgonj – the district town	They go there for official and medical purpose.
Chauhali, Sirajgonj – upazila (sub-district) headquarter	They do not go there except land and police cases due to poor communication.
Shahjadpur, Sirajgonj – nearer upazila headquarter	They rarely go there for business purpose.
Bera, Pabna – business centre	They rarely go there for business purpose.
Pabna – old (greater) district headquarter	Few people go there for land administrative purpose.

It seems mobility is available to the char-dwellers during flood because of the well connected waterways. Men cannot move freely because they lose their regular work and stay at their homes to protect their belongings. Severe floods often damage handlooms so that loom workers cannot get work. However, men go to Anayetpur and Koijuri to search jobs. Besides, they go to Shahjadpur more frequently during flood rather than in normal times due to bringing their family members for treatment at the health complex and the child hospital.

On the other hand, though women try to avoid going outside of their homes they have to go to different places for social interaction, including going their father's home and for medical purposes. Women usually go to different places for medical purpose and sometimes for social gatherings. Table-4 describes where and why they go.

Table-4: Destinations of Women and Reasons for Mobility

Places	Reasons
Noahata bazaar, Sirajgonj - local market place	It is the most highly frequented place for women. They generally go there for small shopping tasks in the absence of their husbands and to phone their husbands who work outside of the *char* especially in Dhaka.
Anayetpur, Sirajgonj – a local business centre	It is the second highest frequented place for women. In general, they go there for medical treatment and they think it is cheaper than any other place.
Teghuri, Sirajgonj – the next village	They usually go to BRAC and Manab Mukti Sangastha (MSS); a local NGO; office for getting loans and other benefits.
Shahjadpur, Sirajgonj – next upazila headquarter	They go there with their concerned male guardian particularly for their children's medical treatment.
Chaluhara, Sirajgonj – a neighbour village of Sthal Noahata	It is another prime destination for women. They go there for earth-digging work. Besides, the local CLP office is also there. So they go there for training and meetings as well.
Chauhali, Sirajgonj – upazila (sub-district) headquarter	They go to the local union council situated at Chauhali for getting VGF card, birth registration and relief.
Betil and Gosaibari, Sirajgonj – two nearer villages	They go those villages for visiting their relatives' houses and for cost-effective medical services.
Sirajgonj – the district town	They rarely go there except for major medical purposes.
CLP clinic – within their village	Women identified this location as one of the vital destinations because of their easy access for quick medical prescription.

Though the normal mobility of women is hampered by flood they still have to go to some places. For example, there is no difference between going to Shahjadpur during normal time and flood time. They go to Koijuri and Chaluhara to get shelter and relief. Nonetheless, Chauhali is an exceptional place where women have to go to receive relief and VGF card though they rarely visit in normal time. However, women stay at their home more during flood.

Table-3 and 4 illustrates that the mobility patterns of both men and women are affected by flood.

Daily Responsibilities

Here daily responsibilities mean what the *char*-dwellers generally do, especially for their families. Figure 4 illustrates men work in crop fields and weave-sheds in the morning in normal time and rest of the day they usually pass by smoking, chewing and gossiping with their friends in the market and with family members at home. But during flood, they have no work so that often they pass their time by gossiping and getting rest. They try to minimise their smoking and chewing habits because they do not have enough money in hand. Shop-keepers usually do not want to sell cigarettes and betel leaf on loan.

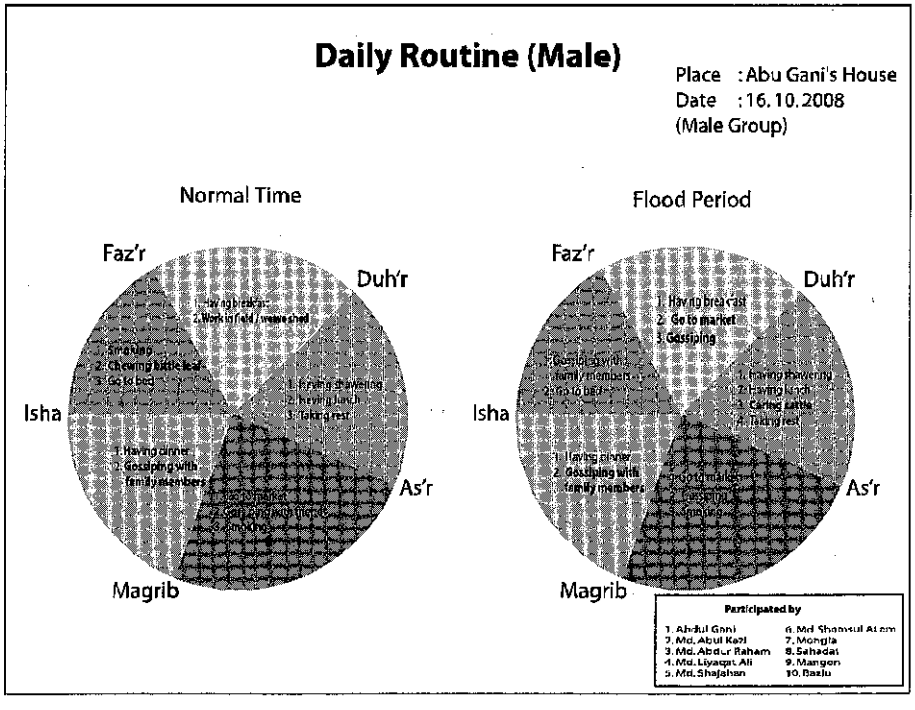

Fig.- 4: Differencebetween daily activitiesof men during normal and flood period

Figure-5 shows women work a lot both in normal time and during flood, especially in their homes. They cook food and clean their homes and look after their children and other members of the household and even their cattle and poultry birds. Besides, they process cotton thread and then if they have the time they gossip with neighbouring women and sometimes chew betel leaf with their husbands at night. On the other hand, during flood, they have to do even more work because often their husbands pass their time reluctantly. They sew carpets and other usable items in their leisure time to earn some money as because most of the men remain jobless during flood. Thus, they cannot manage time to gossip with others or get rest.

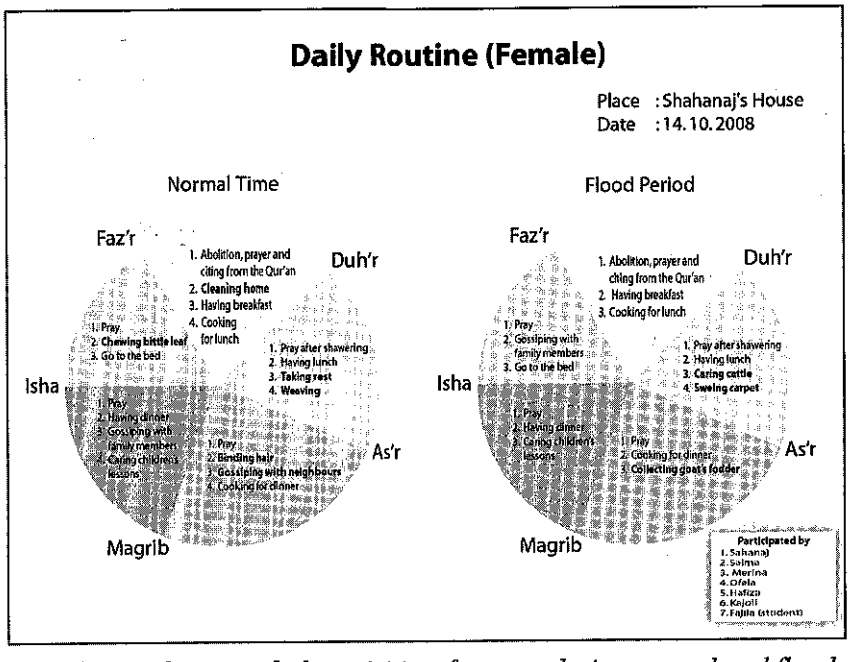

Fig.- 5: Difference between daily activitiesof women during normal and flood period

Figure 4 and 5 shows that there are differences between the daily routine of men and women during flood and normal periods. Women do more work compared to men and most of the work is unpaid and uncounted by outsiders and even by their husbands. Moreover, during flood women bear more responsibilities for their families, because men often do not do enough work even compared to what they do in normal time.

Conclusions

Bangladesh is a flood prone country and the people particularly who live in remote places like river chars are extremely vulnerable to floods. The present study focuses on understanding disaster impacts on the char-dwellers in the Jamuna river basin through a gender lens. The unique contribution of the study is to involve local people in research process through participatory approach rather than conducting conventional research methods.

The male respondents of the study area identify unavailability of work, cattle rearing, scarcity of food and lack of communication as the factors during flood which are mainly related to their livelihoods. On the other end, scarcity of food, drinking water and clothing are the main sufferings of women in floods which related to their culture driven domestic responsibilities.

The government and other stakeholders in disaster management can consider gender-specific vulnerabilities and disaster impacts in their policy and action plan. In this way, gender sensitive community based approach can reduce social vulnerability and enhance resilience for achieving development agenda.

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The Role of Tourism Industry in the Economy of Bangladesh

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Abstract

This study attempts to explore the present and potential contributions of tourism sector in the socio-economic development of Bangladesh. Data have been collected from secondary sources like academic articles, periodicals, reports of related organizations, newspapers, textbooks, concerned websites and other allied materials. Hospitality and tourism sector has significant contributions to the GDP, creating employment opportunities, source of national revenues, foreign exchange earnings, rural development, foreign direct investment, product development, transportation and infrastructural development of Bangladesh. To obtain maximum benefits from this potential sector Bangladesh needs to increase budgetary allocation, investment on transportation and tourism infrastructure development. Promotional activities should be up to date and political stability must be ensured before huge campaign in the international arena. It is expected that the outcome of this study will facilitate the decision makers, planners and researchers to perceive the contribution of tourism industry in the economy of Bangladesh and will also provide some practical measures to improve further contributions.

Introduction

Tourism industry of Bangladesh is growing slowly since 1990s and drawing attention of different stakeholders (Hasan, 1992). It is comparatively a modern phenomenon which plays significant role in different countries through creating employment opportunities, diverse forms of investment, poverty alleviation and maintaining ecological balance (Rahman, 2012). In the recent travel and tourism competitiveness index, the position of Bangladesh is 123rd out of 140 nations (Blanke and Chiesa, 2013) which indicate the improvement of this sector. Between 2006 and 2010 more than 1.5 million tourists visited Bangladesh and the country earned US$ 413 million. The *Lonely Planet* nominated Bangladesh as one of the top ten 'interesting' travel destinations of the world in 2009 and after two years it listed Bangladesh as the 'best value' destination. These evidences describe the potential of hospitality and tourism sector of Bangladesh. Till now Bangladesh is one of the least arrival countries of South Asia

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with the lowest revenue earned from this industry. It implies that there is huge scope of development of this sector and proper development can contribute in diverse ways in the socio-economic development of Bangladesh.

Objectives of the Study

The broad objective of this study was to identify the contributions of tourism industry in the economy of Bangladesh. The Specific objectives of the study were as follows:

i) To explore the forms of contribution of tourism industry in the economy of Bangladesh; and

ii) o find out the scope of further inputs of this sector in the national economy.

Significance of the Study

Tourism contributes directly or indirectly in the economy of most of the countries (Sofique & Parveen, 2009). Tourism of Bangladesh has also miscellaneous impacts on our economy but the data are comparatively unorganized and it is tough to visualize the total scenario. This study attempts to organize relevant and available data to draw a complete picture on the studied issue. It is expected that the findings of the study will be helpful for the national and regional tourism authorities, policy makers, and planners in various ways. Moreover, it will help the future researchers and investigators to conduct more advanced research on this potential sector.

Literature Review

Tourism refers to go one place to another for entertainment or education purposes. For acquiring of knowledge, tourism plays a vital role. The study of tourism is the study of people away from their usual habitat, of the establishments that respond to the requirements of travelers, and of impacts that they have on the economic, environmental and social well-being of their hosts (Wall and Mathieson, 2006). Kandampully (2000) defines tourism as a unique product composite with tangible and intangible services by tourist's experience. In recent times, tourism has been considered as a major component of the economic prosperity of almost all countries (Poon & Low, 2005). Tourism can be classified into several distinct categories. For example: recreational (holiday travel, visiting friends and relatives); cultural (historical, religious and other monuments, lifestyles, festivals); nature based (sun-sea-beach tourism, rural and ethnic tourism, ecotourism) sports or adventure (hiking, skiing, golf playing); health related (medical treatment, spa and wellness, massages, yoga); MICE (meetings, incentives, conferences and events); shopping, official mission, short term education, and other travels (Anon., 2004; Chowdhury, 2010, p. 12). According to Balakrishnan (2009) travel and tourism is the second largest global industry with daily international revenues of approximately two billion US dollar, and investments of 12 percent of world GDP. That is why travel and tourism considered as one of the fastest growing industries (WTTC, 1995). Now a days development of tourism industry is high priority agenda for most of the nations and communities in the globe

(Tabibi & Rohani, 2011). That is why in terms of employment it ranks top as the largest industry in the world (Mowlana & Smith, 1993). Islam & Islam (2006) argued that Bangladesh is a country of Asian region holding high potentiality of tourism. From ancient time it was an attractive destination to the tourists though at present its position is not significant comparing to the international tourism industry. Generally travel and tourism create jobs and contribute to a country's GDP as well as bring capital investment and increase the volume of exports.

Tourism and Economic Development

Tourism offers immense potentiality for employment generation, poverty alleviation and maintaining ecological balance. After the World War II, tourism industry has become one of the most promising economic contributors in the global economy. It is the fastest growing and single largest industry in the world (World Travel & Tourism Council , 2011). Tourism as a multi-faced industry is playing vital role in the global as well as in the individual economic perspective. In the year 1950, the international tourist arrivals were 25.2 million which rose to more than 800 million in the year 2005 and in 1950, the world tourism earning was US$ 2.1 billion and the same stood at US$ 623 in 2004. The total impact of the industry means that, in 2011, it contributed nine percent of global GDP; or a value of over six trillion US dollar, and accounted for 255 million jobs. Over the next ten years, this industry is expected to grow by an average of four percent annually, taking it to 10 percent of global GDP, or some US$ 10 trillion. By 2022, it is anticipated that it will account for 328 million jobs; or one in every 10 jobs on the planet (WTTC/Oxford Economics, 2012). Tourism is now a major source of GDP in many countries like Egypt, Spain, Nepal, and Singapore. Many developed nations are shifting away from manufacturing to service economies. As a result, the share of travel and tourism employment out of total jobs will probably increase which will also increase the tourism's contribution to the total GDP. In recent times, the government of Bangladesh has realized the importance of tourism in its economic and social life (Hossain and Nazmin, 2006). If tourism is given its due honor of industry and both government and private organizations equally come forward for its development, it will open doors of immense possibility for us (Ahmed, 2011).

Tourism in Bangladesh

Bangladesh has a rich collection of tourism supplies to offer the world. It is enriched with unique cultural heritage and numerous historical & archaeological sites. Naturally Bangladesh owns the longest unbroken sandy sea beach in the world with three world heritage sites (Hossain & Nazmin, 2006). The heritage sites are: the eighty-one domed *Shat Gombuj Mosque* of Bagherhat, established by the great Muslim saint Khan Jahan Ali in the 15th century; the largest mangrove forest of the world *Sunderbans*, which is the home of the world famous Royal Bengal Tiger; and unique example of archeological heritage *Paharpur Buddha Bihar*. Just after achieving the independence, the government realized the significance of tourism sector and established the National Tourism Organization in the name of *Bangladesh Parjatan*

Corporation (BPC) under Presidential Order which started its journey in 1973 with limited resources. The corporation was entrusted with the dual responsibility consisted with developing tourism infrastructures and promoting Bangladesh as a tourist destination (Islam M. F., 2004). Other responsibilities of the Corporation included regulation and operation of tourism activities in Bangladesh. The following table describes the present status of the tourism sector of Bangladesh:

Table-1: Travel and Tourism Indicators of Bangladesh

Travel & tourism Industry (estimated)	***Absolute va lue***			***Percent of total***			***GDP growth forecast (2013 – 22)***
	2008	***2010***	***2012***	***2008***	***2010***	***2012***	
T&T industry GDP (US$ millions)	1185	1613	2,756	1.6	1.7	2.3	6.1
T&T industry employment (1,000 jobs)	801	984	1,377	1.2	1.3	1.9	2.9
Travel & tourism Economy-2012 (estimated)							
T&T economy GDP (US$ millions)	5,775			4.7			6.5
T&T economy employment (1,000 jobs)	2,992			4.1			3.2
International tourist arrivals (000), 2010	303.0			-			-
International tourism receipts (US$, millions), 2011	87.1			-			-

Source: (Blanke & Chiesa, 2013)

The table shows that the travel and tourism industry is growing in a good pace in spite of less organized efforts of developing and promoting it to the target markets. In 2008 this industry had contribution to GDP only US$ 1185 millions whereas just after four years it has been US$ 2,756 millions. And the expected growth of this sector to the GDP is really fascinating; in the next decade it will be 6.1 percent which very impressive for a developing country like Bangladesh. Regarding employment the trend is little bit slower but it is also in very positive trend. It has been 1.9 percent of total employment which is expected to be 2.9 percent in the next decade. As economic sector travel and tourism has a great contribution (4.7 percent) to the national GDP which is expected to be 6.5 percent in the next decade. For creating employment opportunities it keeps very significant role (4.1 percent) but with the increasing size of the industry the number of employment might be reduced (3.2 percent) in the next decade. Amount of international receipts is comparatively lower (US$ 87.1 millions) than neighboring

countries on against of 303,000 arrivals of international tourists. It means the tourists are spending less during their stay in Bangladesh. Earlier Bangladesh recorded 207,662 inbound tourist arrivals in 2005. In terms of region majority of the tourists originated (BPC, 2007) from South Asia (99,459), followed by Europe (48,961), East Asia and Pacific (35,976), America (18,673), Middle East (2,861) and Africa (1,732). In 2010, Bangladesh recorded 303,386 inbound tourists which is the signal of getting back from the plunge of the previous year. The following table shows the visitor arrivals & foreign exchange earnings in Bangladesh in last decade:

Table-2: Visitor Arrivals and Foreign Exchange Earnings (US$ Millions)

Year	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Arrivals	207,199	207,246	244,509	271,270	207,662	200,311	289,110	467,332	267,107	303,386
Revenues	50	48	57	67	70	80	76	84	69	76

Sources: Bangladesh Parjatan Corporation, World Economic Forum & Special Branch

Data show a fluctuating positive trend which is impressive growth rate for a new market entry like Bangladesh. Travel & tourism economy is ranked 80 in absolute size worldwide; 169 in relative contribution to national economies; 22 in growth 2013 forecast; 12 in long-term (10-year) growth (WTTC, 2013). According to BPC (2007) there are at least 43 tourist destinations in Bangladesh with natural, cultural and archeological interests. Most of these destinations contain outdoor recreations on its natural setting, attractive to both domestic and foreign tourists. Although BPC has taken various development activities of tourism infrastructures, this sector requires more investment to be competitive. Establishing hotel, motel or resort is not only aspects of tourism development; BPC needs to do many other timely things. The Travel & tourism competitiveness report - 2013 describes the infrastructural situation of Bangladesh in the following way:

Table-3: Infrastructural Situation of Bangladesh

The travel & tourism competitiveness factors	***Rank (out of 140)***	***Score (Out of 7)***
Business environment and infrastructure	109	2.9
Air transport infrastructure	113	2.3
Ground transport infrastructure	65	3.8
Tourism infrastructure	127	1.6
Information and communication tech. infrastructure	128	1.7
Price competitiveness in the travel & tourism industry	16	5.2

Source: (Blanke & Chiesa, 2013)

It can be said that tourism industry is identified as one of the most promising contributors in the economy of Bangladesh and it offers many development opportunities. With strong backward and forward economic linkages, tourism industry can stimulate broad-based economic growth

and become a rich source of development benefits, generating increased income, foreign exchange earnings, economic diversification and job creation.

Tourism Products of Bangladesh

Bangladesh has a lot of products to offer to the domestic and international tourists. Accommodation facilities (e.g. hotels, motels, resorts) have immense potential. Amusement items e.g. Adventure/safari/amusement parks, bars and night clubs, sporting items offer entertainment opportunities for the tourists. Enriched shopping malls, super markets and restaurants offer luxurious as well as consumer products like foods & beverages, clothing's. Besides, various operators offer comfortable coach, cruise, and air services. Tourists also have great affection to handicrafts, souvenirs and to various local and tribal products of different destinations. Travel agents, tourist guides, security services help the tourists to make their journey enjoyable and secured. Health and medical services are also provided for the tourists in different spots.

Methodology of the Study

The design of the study was primarily based on secondary data. Moreover, the observations of the researchers have also been tried to accumulate to summarize, organize, and explain the available data. To collect the secondary data, published reports of Bangladesh Porjatan Corporation, Ministry of Civil Aviation and Tourism, World Travel & Tourism Council, Association of travel Agents of Bangladesh, Bangladesh Bureau of Statistics, UNDP, UNESCO, World Tourism Organization, and World Economic Forum have been studied. Tourism related domestic and international journals, periodicals, newspapers have also been reviewed. Web contents of BPC and other tourism related sites (e.g. official websites, blog posts, pages in professional and social media) were critically evaluated. In addition, for theoretical review and analyses textbooks and related materials were consulted which are properly mentioned in references section. Available data have been tabulated, analyzed, and presented by using data transformation or data conversion process. In this way, scattered data have been organized and summarized to address the research objectives.

Findings of the Study

The tourism industry is potentially a major source of foreign exchange, contributing considerably to a favorable balance of payments (Rahaman, 2010). The level of gains totally depends on the usage patterns and efficiencies of managing the existing resources. Bangladesh is till now in primitive stage of tourism development (Hamid & Akter, Awating Jaflong: A genuine cave for nature hunters, 2008), it is learning through different initiatives. The overall scenario of success and failure is mixed but till now the achievements are not negligible. The findings of the study are divided into two sections. First, to draw a picture of present contributions and the second part is for the potential scopes of development:

The Role of Tourism Industry in the Economy of Bangladesh

Contribution to GDP

Tourism in Bangladesh is managed by *Bangladesh Parjatan Corporation* under the Ministry of Civil Aviation and Tourism. The economic contributions of tourism to the national economy are not properly studied by these organizations. Last few years, *World Economic Forum* is publishing country report with the assistance of CPD. Latest report estimated that the direct contribution of travel & tourism to GDP in 2012 was US$ 2756.2 million (2.3 percent of GDP).

Table-5: Travel and Tourism Economic/Industrial Indicators

Years	Travel and Tourism Economy (estimates)			Travel and Tourism Industry (estimates)	
	GDP (US$ millions)	*Percent of total*	*Annual growth (%, forecast)*	*GDP (US$ millions)*	*Percent of total*
2008	2964	3.9	5.5 (2009-2018)	1185.0	1.6
2010	3786	3.9	6.4 (2011-2020)	1613.0	1.7
2012	5775	4.7	6.5 (2013-2022)	2756.2	2.3

Source: The TTCI Reports of 2009, 2011, and 2013.

The given data on table 5 show that the trend of growth is positive though most of the cases, even the developed countries, are facing very critical situation for the economic recession from 2008. *Bangladesh Parjatan Corporation* in a report (2004) on *Tourism vision 2020* forecasted about the steady growth of tourism sector. This organization expected contribution of tourism to the overall development through job creation, poverty reduction, increasing national GDP, development and conservation of tourism. The trend proves that sincere initiatives can bring much better returns on investment in tourism industry of Bangladesh.

Contribution to Employment

The World Travel and Tourism Council reported (2013) that travel and tourism industry in Bangladesh directly generated 1377 thousand jobs in 2012 which is 1.9 percent of total employment and this is forecast to grow by 2.9 percent in 2013. This includes employment by hotels, travel agents, airlines and other passenger transportation services (excluding commuter services). It also includes, for example, the activities of the restaurant and leisure industries directly supported by tourists (Blanke & Chiesa, 2013). Another report predicts that by 2023, travel & tourism will account for 1785 thousand jobs directly, an increase of 2.9 percent per annum over the next ten years. The total contribution of travel & tourism to employment (including wider effects from investment, the supply chain and induced income impacts) was 2373 thousand jobs in 2010 and 2714.5 thousand jobs in 2012 (3.7 percent of total employment). It also forecasts to raise by 4.2 percent in 2013 to 2829.5 thousand jobs

(3.8 percent of total employment). By 2023, travel & tourism sector may create 3891 thousand jobs (4.2 percent of total employment), an increase of 3.2 percent per annum over the period (WTTC, 2013).

Visitor Exports and Investments

The travel business generates the benefits of international trade which foster domestic and foreign investments. Such investment expedites the flow of capital, technology, skills, people, expertise, and demand for local supplies to the economy. It also improves the trade balances. Travel & tourism have attracted capital investment of more than US$ 1000 million in 2011. This is expected to rise by 0.5 percent in 2013, and rise by six percent per annum over the next ten years. According to WTTC, Bangladesh's travel and tourism industry earned US$ 539 million or 3.8 percent of the country's total exports in fiscal 2006-07. Visitor export is a significant component of the tourism industry; in 2012 Bangladesh gained more than US$ 1050 million from visitor exports.

Improvement of Quality of Life

Tourism creates employment and therefore increases the income of host communities. Through employment generation the purchase power parity increases which contribute in the 'quality of life' of the local inhabitants. Tourism related jobs are getting acceptance all over the world and higher educated people are entering into this profession. Tourism development also encourages entrepreneurship in the concerned areas. Tourism development benefits the rural and peripheral areas of the state as media draw attention to provide adequate facilities to the tourists. It encourages the local and central governments to develop communication and transportation systems; safety and security also become a major concern of the administration. It also creates the opportunities for the local people and reduces disparities through employment of women, youths, tribes, underprivileged groups, and neglected portions of the society. Manufacturing regional handicraft items, selling fruits or food items motivate community participation which has positive impact on regional and national development. It reduces burden on the central government and quality of life enhances gradually.

Stimulation of Infrastructural Investment

Tourism development expedites the development of general infrastructural facilities with the tourism infrastructure development. For example, improvement of transportation facilities (e.g. car or boat rental) for the tourism industry adds value considerably to the national communication system. Specialization in tourism transport services also improves the overall standard of transport quality. *Bangladesh Parjatan Corporation* operates 39 tourism arrangements on commercial purpose. It is also planning to build motels in Chittagong beach area, Rangamati, Jaflong and Sona Masjid soon. The government has taken an initiative to develop new tourism infrastructures under public private partnership arrangement. Two

projects for setting up of an 'exclusive tourist zone' at Teknaf and a five star beach hotel along with golf course are going to be constructed at Cox's Bazar. Constructions of a motel, a youth hostel and a Buddhist temple have already been completed at Kuakata beach point. Bangladesh's tourism industry can contribute around four percent or over to the country's GDP by 2018 if the government develops infrastructure (Sofique & Parveen, 2009).

Contribution to Foreign Exchange Earnings

The tourism industry is a major source of foreign exchange, contributing considerably to a favorable balance of payments. People from other countries visit Bangladesh, enjoy the facilities, spend foreign currency and return home. Except purchasing of gifts and souvenirs, there is very little to be physically transferred. This characteristic of the tourism industry is known as 'invisible exports'. For a country like Bangladesh this characteristic of tourism can play a vital role (Rahaman, 2010). Tourism of Bangladesh is being considered as a foreign currency earner from last decade because the earlier contributions were very negligible. For example, Bangladesh earned US$ 50 million from travel and tourism in 2001 whereas the country earned US$ 76 million in 2010 (Shawon, 2013).

Product-Development

Tourism product development is designed to increase the income in the sector by implementation of a comprehensive plan of action that will guide towards dealing with estimated increase in business over the short, medium and long-terms. In Bangladesh, attempts are being made to export 'non-traditional products' such as handicrafts, souvenirs and other cottage industry products. Several organizations are also putting great efforts into popularizing and marketing these products abroad (Islam M. F., 2004). Cottage industries are showing spontaneous growth in the villages of Bangladesh and are playing a significant role in the economy. In this case, the most remarkable difficulty is improving the marketability of such products. Tourism evidently offers better marketing opportunities and encourages production and the growth of small industries. The development and management of tourist destinations should consider the needs and interests of all stakeholders (e.g. local or rural community, entrepreneurs, investors, governments, tourists and others) in the system. Tourism development also encourages product diversification and market expansion direct and indirect way.

Development of Service Sector

Tourism contributes to the development of service sector all over the world. Tourism is mostly a service industry and it is labor oriented than other manufacturing sectors. Usages of modern technologies may replace human beings in other industries largely, but in the tourism sector, the key factor is personal service. Besides, customizations of choices in tourism sector rarely allow automation. For this, as a labor-intensive economy, the tourism services can create employment opportunities and a productive labor force to a greater degree comparing to other sectors.

Services and facilities are the main products of tourism industry; taxation and other levies on consumer goods, especially luxury products, can be more beneficial to the economy of Bangladesh.

Work Efficiency

Recreation and holidaying help to develop the mental health of people and improve work efficiency. In a labor-intensive economy such as Bangladesh, work efficiency is a vital factor in enhancing overall production. Tourism is an excellent way of achieving such benefits due to its very wide range of recreational activities. European and Americans pass long time for vacation each year and they do better works during their working period. So, in Bangladesh perspective, the people should find some leisure periods and pass time on recreation activities which will have positive impact. Though political instability hampers regular activities and people and sometimes has to work on holidays in their workplace. Moreover, they do not get the assurance of returning on time after touring from the desired place. Such uncertain situations discourage them to plan for touring in a particular season or a destination.

Tourism in Balanced Development

Community-based rural tourism encourages a balanced development in a country. In Bangladesh it is highly required for the economic development. Governments generally prefer to spend national budgets to the urban areas for different reasons. Rural people always stay far from the lime light. In this case, tourism can help them largely. For example, the roads and communication systems of Kuakata was out of focus for long time. But after getting the recognition as a tourism destination, the local and regional authorities have tried their best to manage funds from government and now overall situation is better than the last decade. In this way, the hilly areas, underprivileged north Bengal can be developed through tourism development. Development of peripheral tourism might play significant role to mitigate poverty, promote of indigenous culture and heritage, develop of rural livelihood, ensure education and training for all, and develop human resource (Buhalis, 2000). Because of its multi-faceted nature, tourism may foster the solid economic development. The income effects of tourism may give rise to wide variations in income multiplier.

Prospects of Tourism in the Economy of Bangladesh

If adequate facilities are provided, tourism sector of Bangladesh might become a major contributor in the economy of Bangladesh. It is estimated that by 2023, if current growth rate continues the total contribution of tourism will be 4.7 percent of GDP and 4.2 percent of total employment and by that time tourists arrivals may rise significantly. It may contribute to decrease unemployment equally to the rural as well as to urban people where tourist's spots are located. If this sector properly explores huge number of tour guides and tour operators will be needed to provide services. As the tourists have great attractions to local and tribal products there is a great possibility to raise income level of local and tribal people through product

diversification. In many countries like Indonesia and Malaysia rural tourism has been established as a very popular segment. As Bangladesh is constructed with thousands of villages, it has huge prospect and some planned steps can diversify rural tourism and can attract a good number of international tourists. Some rural areas of Sylhet and Banderban areas can be given priority in the first stage as these areas are close to other tourist attractions.

Bangladesh may establish world-class health centers (medical tourism) where people from south Asian countries will receive health facilities and hereby we can earn a huge amount of foreign currency. Besides, establishment of world class conference centers (MICE tourism) may attract regional conferences of multinational companies. Star (five and seven star) Hotels will attract business giants to hold their meetings and enjoy leisure time. According to Bangladesh Parjatan Corporation (2009), now five star hotels offer accommodation at US$ 100 and above, mid range hotels offer US$ 70-100 and Budget hotels offer around US$ 25 and below. These rates may be very attractive to the low cost travelers of neighboring countries. Establishment of night clubs and bars may add value to the leisure tourists. Bangladesh is not properly offering its longest sea beach of Cox's Bazar and world largest mangrove forest of Sundarban to the target groups. Appropriate policies and promotional activities will unquestionably attract more international visitors. Bangladesh can build venues and infrastructure to promote sports tourism in Bangladesh by seeking both local and foreign investments. Those investors can introduce world class cruise vessels to take tourists to the Saint Martin and Sundarban. Exclusive tourist zone or tourist village may also be helpful for tourism as well as economic development.

Conclusions

Tourism industry is moving forward in an unplanned and unorganized way for long time in Bangladesh. It can really contribute in diverse way of the national development. To do so the tourism sector should be adjusted into national development and economic policymaking through comprehensive national tourism strategy. Creating effective & efficient sector based policies for infrastructure, employment, trade, investment, education, quality standards, and cultural and environmental protection, with a view to achieving mutually supportive policies and sustainable development can ensure desired role in the economy of Bangladesh.

Recommendations

To utilize the potentials of tourism sector, concerned authorities need to work out more sincerely. For the low performance of BPC, Bangladesh Tourism Board has been established but till now this is filled with the bureaucrats, most of the cases, who have no passion or working experience for tourism sector. To uphold this industry into a competitive position, a group of devoted and sincere people should be assigned with adequate supports. Besides, political stability must be ensured to attract tourists. Political instability and collision have substantial negative effect on tourist's arrival (Egypt is the best example of such vulnerability).

Moreover, success of tourism sector not only depends on attracting international tourists but also attracting renowned investors. More or less Bangladesh has failed to attract mega investment in this sector. If they come into Bangladesh, after spending huge amount of money, they will promote their site to the international media which will have overall positive impact on the economy of Bangladesh. Before inviting international tourists we should develop the basic facilities of the tourists in the potential tourist spots. Otherwise, they will speak against (negative word of mouth) tourism of Bangladesh which will have strong effect on the potential tourists.

Tourism sector needs to take appropriate communication initiatives to its target groups. Tourism promotional offices should be established in the major tourist generating countries like China, UK, German, USA, Japan, Australia because these countries produce more than 70 percent of the world's outbound tourists. Negative country image is a great barrier for tourism promotion in the international arena. So, long term plans should be taken and should handle carefully to get positive coverage on global media. Our Embassies and Consulates should be active so that they work on forming national image rather than destroying through ill activities. Our positive sides should be presented in the international media instead the image of over population, political instability, natural calamities etc.

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Hydrophobic Effects of Oily Water on some Soil Properties

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Abstract

Hydraulic conductivity is an important property of soil involved in the behavior of soil-water flow systems. The hydraulic conductivity of unsaturated soil plays an important role in determining the maximum infiltration rates, field capacity, and flow of water to plant roots and drainage of saturated soil. Application of wastewater in irrigation is an important dimension of water resources planning to solve the arising problems of water scarcity throughout the world although soil health is a concern for this. This study investigated the variation of hydraulic conductivity and pH of 10 soils due to the application of oily wastewater, which caused the soils hydrophobic. For this, the saturated and unsaturated hydraulic conductivity of the ten soils was determined by disc/tension infiltrometer both before and after the application of the wastewater. After application of oily wastewater, both the saturated and unsaturated hydraulic conductivity of the soils decreased. The electrical conductivity and pH of the soils increased due to the impact of oily wastewater. The exponent 'α' of the soil hydraulic conductivity function also decreased after application of oily wastewater.

Introduction

An important property of soil involved in the behavior of soil water flow systems is the hydraulic conductivity. Qualitatively, hydraulic conductivity is the ability of the soil to transport water. More precisely, the flux of the water per unit time per unit gradient is known as hydraulic conductivity. It depends on the intrinsic permeability of the material and on the degree of saturation. Unsaturated hydraulic conductivity is a measure of how water flows through a soil profile when the soil is not saturated with water. Flow equations describing the unsaturated water movement are more complicated than similar equations describing saturated flow.

Determination of unsaturated hydraulic conductivity has several distinct importances. The hydraulic conductivity of unsaturated soil plays an important role for determining the maximum infiltration rates, field capacity, and flow of the water to plant roots and drainage of saturated soil (Campbell, 1974). An analysis and understanding of these flow systems required

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adequate knowledge of hydraulic conductivity. Hydraulic conductivity is also used for estimating solute transport through soil, ground water modeling and leaching of saline soils. Several important water flow processes in agriculture, such as infiltration, evaporation and flow of water to plant roots are governed by unsaturated flow. Measurements of unsaturated hydraulic conductivity of different soils are necessary for better water and nutrient management in agriculture. Farmers of Bangladesh irrigate crop field frequently and often use extra amount of water, which sometime reduces water use efficiency and on the other hand, increases the loss of fertilizer and pesticide from the crop field. Consequently, production cost increases considerably.

Use of the knowledge of soil-water interactions in an unsaturated condition can help to manage these problems to some extent as it describes the supply of moisture and nutrients to plant roots as well as movement of pesticides and nutrients through the soil at different water contents.

Numerous methods for determining soil hydraulic properties are now available (Bouma *et al.*, 1983; Dirksen, 1991; Reynolds and Elrick, 1991). A variety of direct methods has been developed to determine unsaturated hydraulic conductivity under steady-state condition. These methods are time consuming since experiments have to reach several steady-state conditions. Faster non-steady and quasi steady-state methods include hot air method, sorptivity method, the method of Abuja and El-Swaify (1976) and several evaporation methods. Recently, disc permeameters (also called disc infiltrometer or tension infiltrometer) have became popular to estimate the hydraulic conductivity of soils across a range from saturation to few hundred millimeters of suction head and to quantify the role of macro pores during infiltration.

Hydrophobicity of soils is a well-known phenomenon worldwide. It occurs under a variety of climatic conditions and is well documented in the scientific literature (Wallis and Horne, 1992). It can be induced by particulate organic matter (OM) present in soil (McGhie and Posner, 1980). Naturally occurring OM can originate from different vegetation or fungal hyphae (Bond, 1964; Chan, 1992). Water-repellent soils have also been found to develop in the absence of vegetation cover when organic matter was introduced via irrigation with wastewater (Chen *et al.*, 2003; Tarchitzky *et al.*, 2007). Soil hydrophobicity is a characteristic of some soils, allowing them to repel water and thus affects soil water content and groundwater recharge. Soil water repellency is known to be a dynamic property, which varies in the short term or between seasons. In the short term, its temporal nature is often studied based on soil-water content, assuming that it is re-established after the soil dries out. The re-establishment process was studied on: (i) natural water-repellent soils subjected to different leaching rates; and (ii) wettable sand subjected to wetting–drying cycles with dissolved organic matter solution. The effect of hydrophobicity continues to act after water penetrates the soil during infiltration and when water is retained in the soil. In fact, one of the primary effects of water repellent soils is a reduction in the rate of water infiltration.

Objectives of the Study

The overall objective of this study was to evaluate the impact oily water on the unsaturated and saturated hydraulic conductivity, electrical conductivity and pH of soils at 10 locations of BAU campus. The specific objectives were:

i) to determine the hydraulic conductivity of 10 soil samples before and after application of oily water;

ii) to determine the electrical conductivity and pH of the soils; and

iii) to compare the hydrophobic effects of oily water on the measured soil properties.

Methodology

Infiltration rate was measured at 10 sites of Bangladesh Agricultural University (BAU) campus and farm by disc infiltrometer before and after application of oily wastewater. The disc infiltrometer is designed to measure the unsaturated flow of water into soil rapidly, accurately and easily. Applications of the infiltrometer include measurement of macro pore and preferential flow, estimate of soil structure, and characterization of the soil hydraulic conductivity water potential relationship. The 20-cm diameter infiltrometer has been designed to operate in two modes. In mode one, the infiltration disc is separated from the water tower. In mode two, the infiltration disc is attached to the bottom of the water tower, using the supplied connector. Operating the infiltrometer in mode one is especially advantageous when taking measurements under windy condition. If the infiltration disc is attached to the water tower, even a small movement of the water tower by wind, or by accidentally touching it, will affect the contact between the disc and the soil surface and thereby the rate of infiltration of water into the soil. By separating the control tower from the disc, chances of affecting the contact between the disc and the underlying soil are greatly reduced. A second advantage of operating the infiltrometer in this mode is that the weight of the infiltrometer disc is constant during the measurements. In mode two, the weight of the infiltrometer, and thus the pressure on the soil surface, changes during measurements as the water tower empties. Operating the infiltrometer in mode two is advantageous where space is limited, such as in a soil pit or in a small excavation.

In both modes, the water level in the water reservoir can be determined by reading the level on the attached centimeter scale, or by measuring the pressure in the upper end of the water reservoir. The pressure in the air pocket at the top of the water reservoir (always negative) is linearly related to the height of water in the reservoir. A centimeter change in water height means a centimeter change in pressure in the air pocket. Thus, infiltration rates can be monitored by recording pressure changes measured with a pressure transducer with digital read-out (Tensiometer), or with pressure transducers and a data logger over time. Using two pressure transducers, one on top of the water reservoir, and a second one mounted on the infiltrometer disc, gives the most complete information. Using two pressure transducers,

one on top of the water reservoir, and a second one mounted on the infiltrometer disc, gives the most complete information. Using two pressure transducers virtually eliminates bubbling 'noise' which increases measurement precision.

The major components are:

1. The bubble tower, which controls tension at the soil surface,
2. The water reservoir, which empties as water flows into the soil,
3. The disc to establish hydraulic continuity with the soil, and
4. $\frac{1''}{2}$ ID tube between the disc and the water tower and the one way valve in the middle of the tube.

The water level in the water reservoir can be read directly on the centimeter scale attached to the water reservoir. A simple timer or stopwatch is useful to obtain readings at regular time intervals.

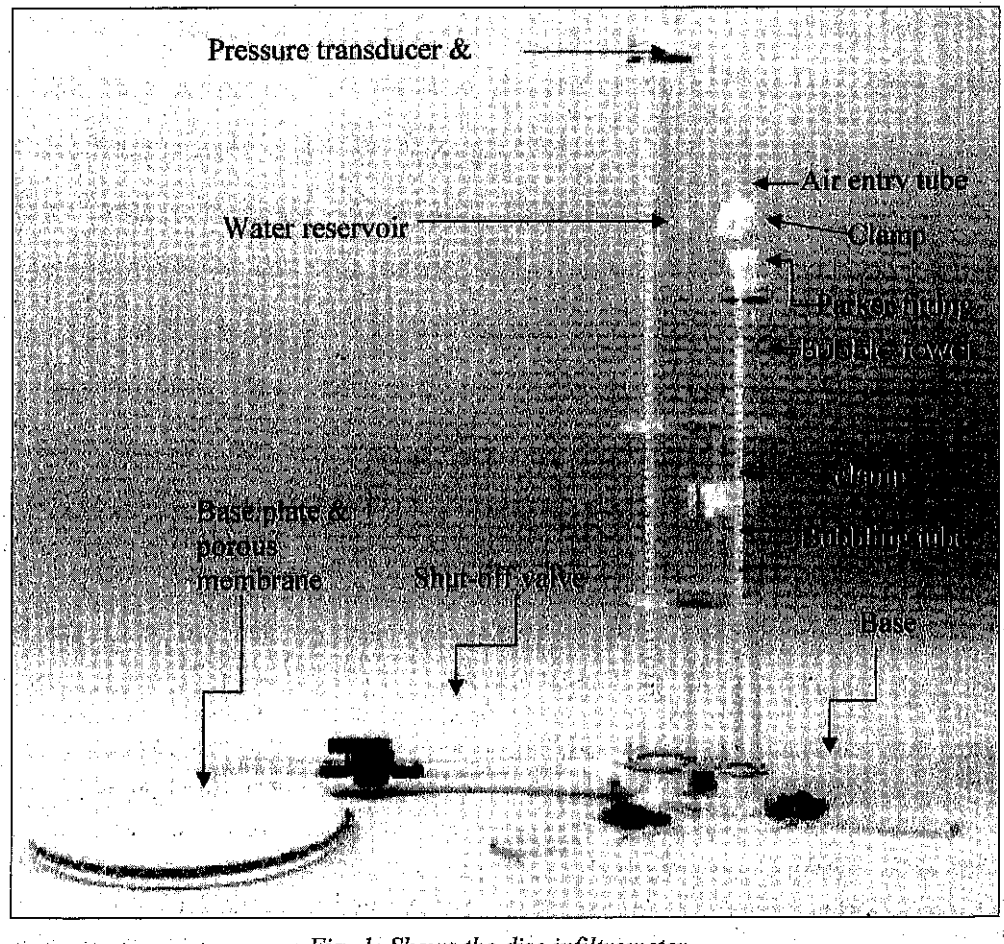

Fig.-1: Shows the disc infiltrometer.

The disc infiltrometer is designed to add water to soil at tensions, which can be set by the operator of the instrument. By performing infiltration experiments at multiple tensions, one obtains data on the unsaturated hydraulic conductivity at the various tensions. The range of tensions that can be set is for practical reasons limited to a fairly narrow tension range, i.e. 0-30 cm water. By setting the tension at or close to zero, one should get an infiltration rate close to the saturated hydraulic conductivity of the soil. Thus the disc infiltrometer can also be used to estimate the saturated hydraulic conductivity.

Before placing the infiltrometer on the site where a measurement is to be made, the site was leveled and cleaned from debris. A ring was placed on the leveled surface, and the area within the ring was filled with fine sand from of 1-2 mm thickness. The sand was leveled carefully, and the ring removed. A perfect flat surface, 20 cm in diameter, was formed for placement of the infiltrometer. The sand layer should result in good contact between the base of the infiltrometer and the soil below. By raising or lowering the tube in the bubble tower, the tension that will be maintained at the bottom of the base plate can be set. The maximum tension is generally less than 30 cm. Many researchers start with the highest tension (often 20 cm). At the highest tension, the hydraulic conductivity is the lowest, and thus it may take some time for the instrument to start "bubbling".

The disc infiltrometers are designed to collect data manually, or automatically. In our experiment, data were collected manually by recording the water level in the supply tower over time. The data were recorded for different suctions and measurements were carried out until steady state flow occurred for each suction.

Ten soil samples were collected from the 10 experimental sites and texture of these soils was determined by hydrometer method as well as textural classes of those soils was determined and given in table-1

Table-1: Percentage of Sand, Silt and Clay along with the Textural Class of the Soils used in this Study

Site	1	2	3	4	5	6	7	8	9	10
% Sand	57.496	55.496	47.496	47.28	61.136	49.712	35.424	25.424	65.352	65.208
% Silt	36.216	38.216	45.36	46.432	32.72	44.00	56.288	62.288	29.36	29.504
% clay	6.288	6.288	7.144	6.288	6.144	6.288	8.288	12.288	5.288	5.288
Textural Class	Sandy Loam	Sandy Loam	Loam	Loam	Sandy Loam	Loam	Silt Loam	Silt Loam	Sandy Loam	Sandy Loam

Determination of soil pH and electrical conductivity: Saturation extract of soil samples which were collected from 10 experimental sites both before and after oily wastewater application were used to determine pH and EC with a pH/conductivity meter.

Theory of infiltration data analysis: The following method based on Wooding's work (1968) was used to calculate the hydraulic conductivity versus water content relationship from unconfined infiltration. Wooding proposed the following algebraic approximation of the steady-state unconfined infiltration rates into soil from a circular source of radius r (cm)

$$Q=\pi r^2 K\left[1+\frac{4}{\pi r\alpha}\right] \qquad (1)$$

where, Q = the volume of water entering the soil per unit time ($cm^3\ hr^{-1}$)
K= the hydraulic conductivity, cm hr^{-1}
A= a parameter, and
h = the matric potential, cm

The unsaturated hydraulic conductivity of soil varies with matric potential h (cm) as proposed by Gardner (1958):

$$K(h)=K_{sat}\exp(\alpha h) \qquad (2)$$

Although Eq. 1 can be used for unsaturated and ponded infiltration, Eq.2 applies only for $h \leq 0$. With the disc infiltrometer, one measures the volume of water (Q) entering the soil per unit time through the porous membrane at a minimum of two tensions, e.g. h_1 and h_2. For unsaturated soil, and upon replacing K in Eq.1 with $K_{sat}\exp(\alpha h)$, and after substitution of h_1 and h_2, respectively for h in the combined equation, one obtains:

Where K_{sat} is the saturated hydraulic conductivity (cm hr^{-1}).
α is the soil hydraulic conductivity function

$$Q(h_1)=\pi r^2 K_{sat}\exp(\alpha h_1)\left[1+\frac{4}{\pi r\alpha}\right] \qquad (3)$$

$$Q(h_2)=\pi r^2 K_{sat}\exp(\alpha h_2)\left[1+\frac{4}{\pi r\alpha}\right] \qquad (4)$$

Dividing Eq.4 by Eq.3 and solving for α yields:

$$\alpha=\frac{\ln[Q(h_2)/Q(h_1)]}{h_2-h_1} \qquad (5)$$

Because $Q(h_1)$ and $Q(h_2)$ are measured, and h_1 and h_2 are known, α can be computed directly from Eq.5. With α known, one can now calculate K_{sat} from Eq.3 or Eq.4. Once K_{sat} and α are known, their values can be substituted in Eq.2, yielding the relationship between hydraulic conductivity and tension for the soil. This relationship can be used to calculate the unsaturated

conductivity at the desired tensions. Note, however, that the K_{sat} value obtained with the above method may be different from the value obtained for K_{sat} if measured directly. One reason is that the relationship of K (h) versus h is often not liner near h=0.

Results and Discussions

The effects of wastewater on some properties of soils at 10 sites were measured. The observed results have been presented, interpreted and discussed in this chapter.

Soil pH and EC

The pH and EC of the soils at 10 locations before and after wastewater application are given in Table-2.

Table-2: Soil pH and Electrical Conductivity before and after Application of Oily Wastewater

Site		1	2	3	4	5	6	7	8	9	10
Textural Class		Sandy Loam	Sandy Loam	Loam	Loam	Sandy Loam	Loam	Silt Loam	Silt Loam	Sandy Loam	Sandy Loam
Before wastewater application	pH	6.76	6.70	7.96	8.00	6.94	7.15	7.56	7.15	7.62	6.61
	EC (dS/m)	0.00	0.03	0.13	0.12	0.07	0.13	0.11	0.09	0.05	0.04
After wastewater application	pH	7.12	7.26	8.02	8.17	7.71	7.18	7.42	7.04	6.74	7.63
	EC (dS/m)	0.05	0.03	0.09	0.13	0.10	0.10	0.05	0.07	0.09	0.10

Both pH and EC of the soils increased due to the effect of wastewater. The pH increased by 0.03 to 1.02 unit and EC increased by 0 to 0.06 unit due to the application of oily water.

The Exponent α and Saturated Hydraulic Conductivity

The exponent α of the soil hydraulic function and saturated hydraulic conductivity of different soils before and after application of wastewater are summarized in Table-3.

Table-3: The Exponent α, Saturated Hydraulic Conductivity (Ksat) of Different Soils before and after Oily Water Application

Sl. No.	Soil texture	Before wastewater application		After wastewater application	
		α	K_{sat} (cm/hr)	α	K_{sat} (cm/hr)
1	Sandy Loam	0.080	5.735	0.028	0.248
2	Sandy Loam	0.061	5.485	0.066	3.163
3	Loam	0.070	2.282	0.037	1.423
4	Loam	0.061	1.792	0.023	0.513
5	Sandy Loam	0.066	5.374	0.041	2.034
6	Loam	0.077	3.648	0.056	1.429
7	Silt Loam	0.137	4.594	0.060	0.437
8	Silt Loam	0.053	0.911	0.136	4.069
9	Sandy Loam	0.103	2.820	0.012	0.266
10	Sandy Loam	0.031	1.607	0.032	0.884

It was observed that the exponent (α) decreased in 9 cases and increased in one case. The saturated hydraulic conductivity (K_{sat}) decreased for nine soils and increased for one soil. The oil in wastewater repelled water flow through the soil pores. This is equivalent to the clogging of the soil pores. This resulted in reduced saturated hydraulic conductivity (K_{sat}) in the soils.

Unsaturated Hydraulic Conductivity

The exponent α and saturated hydraulic conductivity, K_{sat} were calculated from Eq.2. From these values, an equation for calculating unsaturated hydraulic conductivity was derived for each soil type. The exponent and saturated hydraulic conductivity were constant for a particular type of soil. But, unsaturated hydraulic conductivity varied with suction head for each soil type. The equations of unsaturated hydraulic conductivity of different soils before and after application of wastewater are given in Table-3. It is observed that the hydraulic conductivity of both soils decreased after application of oily water. The decrease in hydraulic conductivity might be due to physical clogging of the surface layer of the soils by the oily layer generated on the soil surface. In silt loam soil, the decrease in unsaturated hydraulic conductivity was more pronounced than that in the loam soil.

Table-4: Equation of Unsaturated Hydraulic Conductivity of Different Soils before and after Oily Water Application

Site		1	2	3	4	5	6	7	8	9	10
Soil texture		Sandy Loam	Sandy Loam	Loam	Loam	Sandy Loam	Loam	Silt Loam	Silt Loam	Sandy Loam	Sandy Loam
Equation	before wastewater application	K_h=5.74e 0.08h	K_h=5.89e 0.06h	K_h=2.28e 0.07h	K_h=1.79e 0.07h	K_h=5.38e 0.07h	K_h=3.65e 0.08h	K_h=4.60e 0.14h	K_h=.91e 0.06h	K_h=2.81e 0.10h	K_h=1.60e 0.03h
	After wastewater application	K_h=.25e 0.02h	K_h=3.16e 0.07h	K_h=1.42e 0.04h	K_h=.51e 0.02h	K_h=2.03e 0.05h	K_h=1.43e 0.06h	K_h=.44e 0.06h	K_h=4.06e 0.13h	K_h=.27e 0.01h	K_h=.89e 0.03h

Variation of K_{sat} before and after Oily Water Application

The saturated hydraulic conductivity of a particular soil is constant. The saturated hydraulic conductivities of the soils at 10 sites before and after wastewater are plotted in Fig.2. It is observed that the saturated hydraulic conductivity decreased after application of oily water. It is due to the fact that the oil in water reduced the soil pores and thus reduced the soil hydraulic conductivity.

Variation of Exponent α of Soil Hydraulic Function

Figure 3 illustrates the variation of the exponent α of the soil hydraulic function (Eq.2). It is observed that α decreased after application of oily water except for two soils. The reduced exponent implied that for the same suction, the saturated hydraulic conductivity decreased due to oily water application.

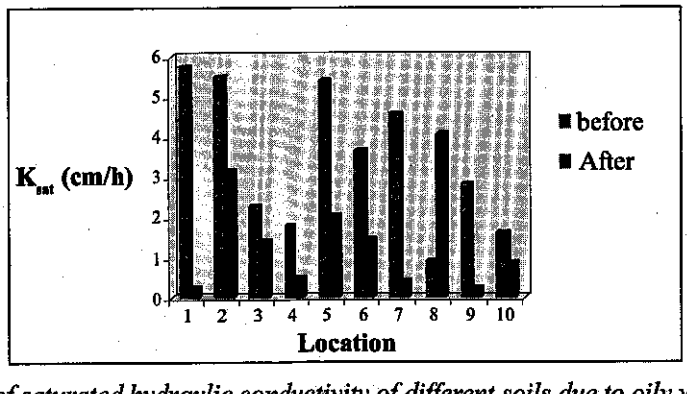

Fig.-2: Variation of saturated hydraulic conductivity of different soils due to oily water application.

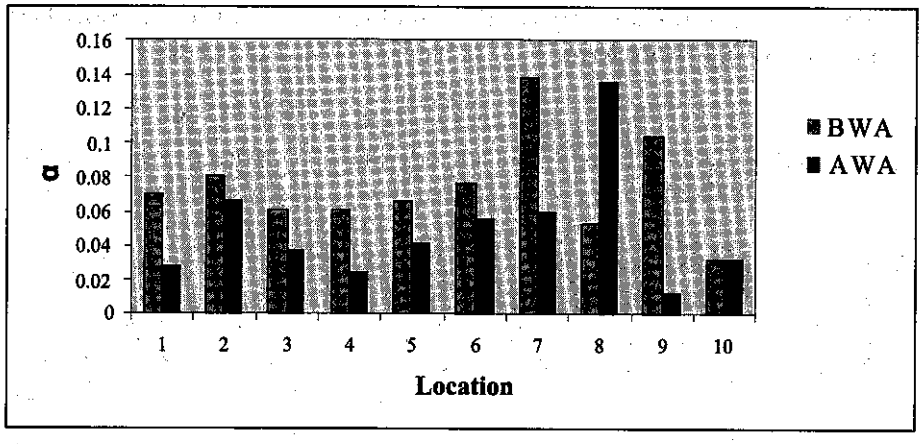

Fig.-3: Variation of the exponent α of different soils due to oily water application (BWA: before wastewater application, AWA: after wastewater application)

Comparison of Unsaturated Hydraulic Conductivity of Different Soils before and after Oily Water Application

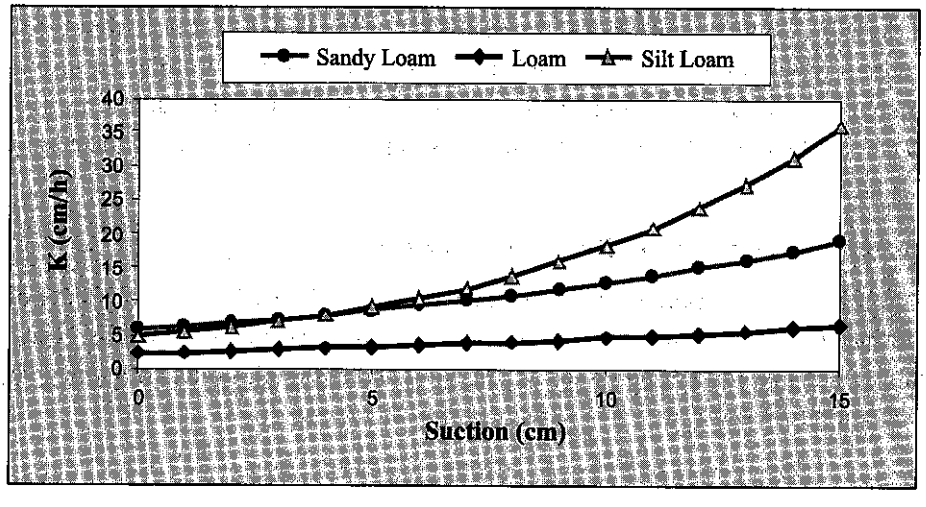

Fig.-4: Unsaturated hydraulic conductivity of different soils before oily water application.

The unsaturated hydraulic conductivity of different soils was calculated for different suction heads. These unsaturated hydraulic conductivities were plotted against the suction heads. The unsaturated hydraulic conductivity of different soils, before and after oily water application, is illustrated in Figure-4 and Figure-5. It is observed that the unsaturated hydraulic conductivity before oily water application in sandy loam was greater than that of the other soil types. But, the saturated hydraulic conductivity after oily water application of silt loam was greater than that of the other soil types. Though silt loam soil had the highest saturated hydraulic conductivity, its unsaturated hydraulic conductivity decreased considerably.

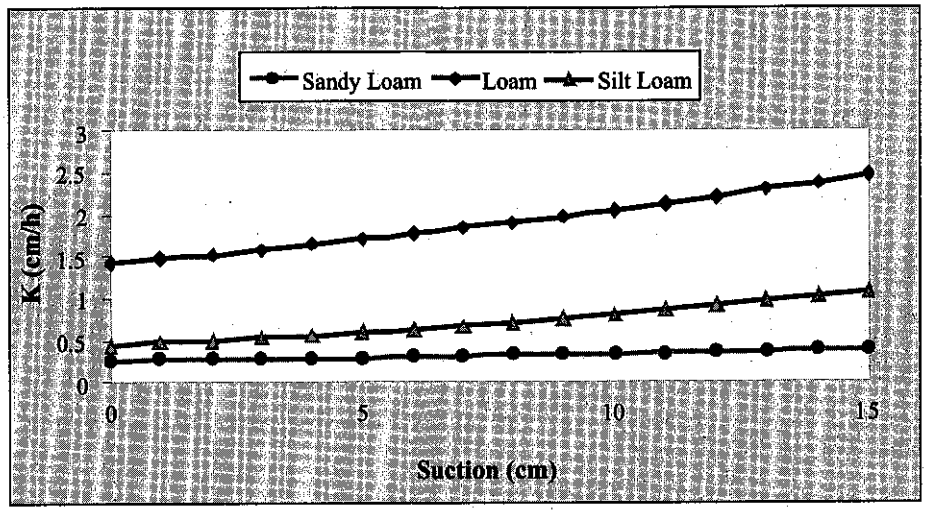

Fig.-5: Unsaturated hydraulic conductivity of different soils after oily water application.

Conclusions

The following conclusions were drawn from this study:

1) The exponent 'α' of the hydraulic conductivity function was greater before oily water application compared to that after oily water application.
2) Saturated hydraulic conductivity was higher before oily water application compared to that after oily water application.
3) Unsaturated hydraulic conductivity of different soils decreased after application oily water.
4) Due to application of oily water, the pH of the soils increased in most cases. Theelectrical conductivity almost remained unchanged.

Recommendations

The following recommendation was put forward from this study:

Detailed studies on the hydrophobic effects of oily wastewater on soil properties are needed before recommending oily wastewater use in irrigation.

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Performance Evaluation of Twin Nozzle Rotating Head Sprinkler

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Abstract

The experiment was carried out to evaluate the performance of twin nozzle rotating head sprinkler in different discharges. The experiment was set up in the yard of the chief farm superintendent (CFS) office at Bangladesh Agricultural University (BAU), Mymensingh–2202. The rain catching cans were placed at the centre of each 1m x 1m grid system in 20m×20m experimental yard to record the water depth for 35 minutes rain. The performance indicators i.e. Distribution Uniformity (DU) and Co-efficient of Uniformity (CU) were measured from the recorded depth of rain under the discharges of 380 cm^3/s, 342 cm^3/s and 257 cm^3/s. Over the varied discharges the better performance was found under higher discharge (380 cm^3/s). The values of CU and DU for this discharge were 54.80% and 38.21% respectively. The relationship was also developed between the discharges and the performance indicators (CU and DU) and a linear relationship was found between the Co-efficient of Uniformity (CU) and Distribution Uniformity (DU).

Introduction

Statement of the problem

Bangladesh is an agricultural country. Agricultural production plays an important role in our Gross Domestic Product (GDP). Agricultural production needs to be increased from our limited land resources to meet the demand of food and fiber of increasing population. Irrigation is an artificial application of water to the soil for providing suitable environment of growing crops in dry areas and during periods of inadequate rainfall. Irrigation plays an important role in crop production.

There are several methods of irrigation like flooding, furrow irrigation, basin irrigation, border irrigation, sprinkler & drip irrigation. Sprinkler system is a modern method of irrigation, which is the most efficient of them. It is a flexible system that can be used to supply adequate moisture for successful crop production (Solomon, K.H. 1990). Sprinkler irrigation systems were first developed in the early 1900's in Europe and USA, with simple sprayers to water parks and lawns. Sprinkler irrigation involves distributing water in pipes under pressure and spraying it

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into the air so that it breaks up into small droplets and falls to the ground like natural rainfall. There are many types of sprinkler system available in market, but the most common is a system using portable pipes (aluminum or plastic) supplying rotary impact sprinkler (Al-Awad, M.C.; Kharrufa, N.S.1987). Scarcity of water is increasing day by day because of increase irrigation area. So loss of water in irrigation needs to be minimized. On the other hand, the efficiency of sprinkler system is higher than any other irrigation system. DU may improve the water use efficiency of an irrigation system. The uniformity of sprinkler irrigation depends on a number of factors, including the sprinkler and nozzle type, the irrigation layout and the environment. The combination of these factors greatly complicates the assessment of irrigation uniformity for a given on-farm irrigation system and a set of environmental conditions. Whenever water is applied with less than perfect uniformity, some parts of the crop will receive more water than the others. If the irrigation system is operated so that the part of the crop receiving the most water has its requirements met, then the remainder of the crop will be under irrigated. Irrigation uniformity is related to crop yield. Insufficient water and excess water both reduce crop yield. Non uniformity causes crop yield to fall below the potential level. So we need a perfect uniformity to get successful yield. The main objective of the study is to measure the performance of the twin nozzle rotating head sprinkler and the specific objectives are as follows:

i) To determine the Co-efficient of Uniformity (CU) of twin nozzle rotating head sprinkler; and

ii) To determine the Distribution Uniformity (DU) of twin nozzle rotating head sprinkler.

Methodology

The yard of the CFS of BAU was used to conduct the experiment. A sprinkler with adjustable discharge controlling valve, discharge measuring instrument, pumping unit and water depth measuring cans were used to accomplish the experiment.

Discharge Measuring Instrument

As the sprinkler discharge is sprayed over a wide range through droplets, it is difficult to measure the actual discharge. Therefore a discharge measuring box was used having a dimensions are 60cm×60cm×30cm. The box was placed on the square stand. The box has a hole at the center to introduce the riser through it. The box has an outlet at one side made by a bend pipe having a diameter of 5 cm to deliver the discharge water. Generally the top of the box is closed by a shutter of Galvanized Iron (GI) sheet. But force of water through the sprinkler was too much which caused leakage into the junction of box & shutter so a *Balti* (bucket) was used around the sprinkler head to confine the water.

Water Depth Measuring Can

Condensed milk cans were used to collect water from sprinkler.

Source of water supply

The pond water of Chief Farm Superintend (CFS) office of BAU was used as a source of water supply to operate the sprinkler system.

Experimental Set Up

The sprinkler was set on a plain ground with a riser at the middle of a square (20 square meters) grid as shown in Figure-1. Cans were placed at the grid points. The distance between the grids point was 1m. A total 441 cans were placed in 21 rows and 21 columns. The experiment was carried out for different discharges.

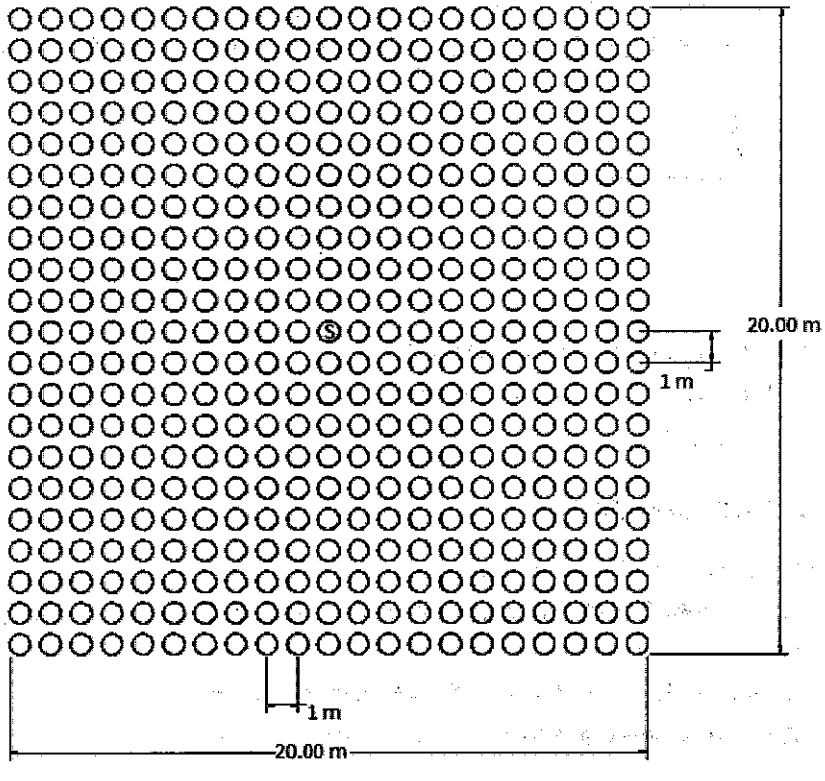

Fig.-1: Grid arrangement of the experiment (S=sprinkler).

Data Collection

Measurement of Discharge

The discharge measuring box was placed on the riser before placing the sprinkler device. Then the sprinkler device was inserted into the riser top and the *Balti* (bucket) held around the sprinkler as shown in Figure-1. The water was supplied through inlet. After sometime when the water was coming out steadily then the discharge was measured by volumetric method using following equation.

$$Q = \frac{V}{t} \quad \text{..... (1)}$$

Where,

Q= Actual discharge (cm^3/s).

V= Volume of water collected (cm^3).

t= Elapsed time (sec)

Co-efficient of Uniformity

CU is the indicator to evaluate the performance of sprinkler system. Several formulas were designed to describe the CU of the sprinkler water distribution and to evaluate their performance. However, the most commonly used Christiansen formula (Christiansen, 1941) was applied in determining CU. The co-efficient of uniformity (CU) can be expressed as:

$$CU = \left[1 - \frac{\sum_{i=1}^{n} |D_i - \overline{D}|}{n\overline{D}}\right] \text{X } 100 \quad \text{..... (2)}$$

Where,

D_i = Water depth in the catch can (mm).

$\overline{D}$ = Mean depth of all observation (mm)

n = No. of cans

Distribution Uniformity (DU)

Distribution uniformity can be expressed as:

DU =Avg. depth infiltrated in lowest one quarter of the area/Avg. depth of water infiltrated ×100..... (3)

Here, infiltrated depth means the depth of water in the container.

DU =Avg. low quarter rate/Avg. catch rate×100 ..... (4)

Results and Discussions

The study was carried out at farm machinery workshop shed to evaluate the performance of twin nozzle rotating head sprinkler. A sprinkler system was installed at the campus of Chief Farm Superintend (CFS) and makes an artificial rain under different discharges. Some sort of catching boxes were placed on the floor at 1.0 m apart. So total 21×21 = 441 numbers of boxes (cans) was placed in a 20m×20m grid. The volume of water accumulated in each cans were measured and the data were analyzed. After analyzing the volume of water catches under the three discharges, the following results were obtained.

Measurement of Water Depth in Catch Can

The measurement was made by volumetrically with 5 ml. plastic syringe. Then the volume was divided by the area of the can to convert into depth. The depth of water collected for different discharges were also plotted as shown in Figure-2, Figure-3 and Figure-4.

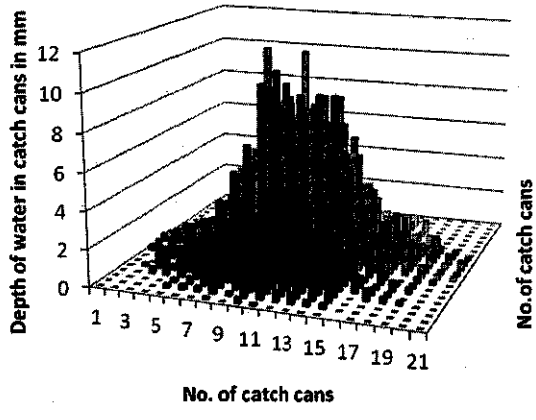

Fig.-2: Distribution pattern of recorded rain depth under 380 cm³/s discharge.

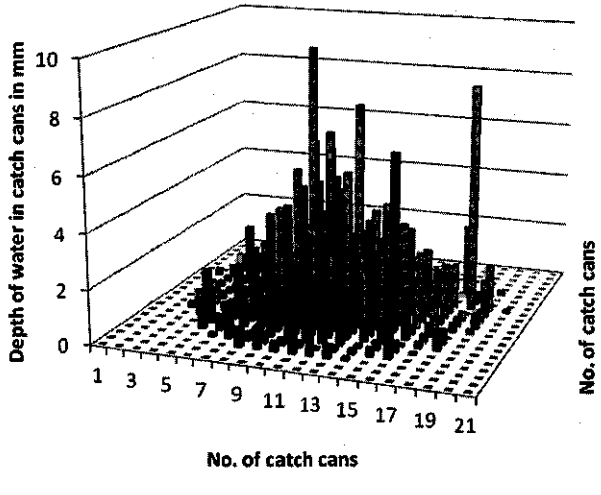

Fig.-3: Distribution pattern of recorded rain depth under 342 cm³/s discharge.

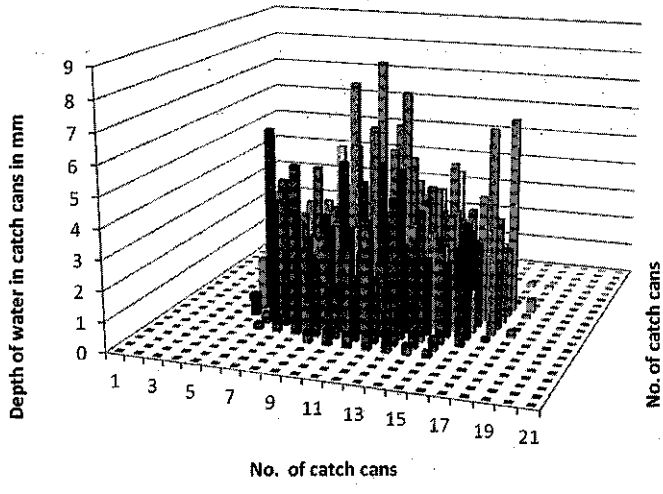

Fig.-4: Distribution pattern of recorded rain depth under 257 cm³/s discharge.

Co-efficient of Uniformity (CU)

The Co-efficient of Uniformity (CU) was calculated by equation (2) for different discharges are presented in (Table-1) shows that the CU varied from 32.50% to 54.80% for the discharge of 257 and 380 cm³/s. The graphical representation of discharges versus CU is shown in Figure-5. In Figure-5 it shows the CU) increases with the increase of discharge. Also a linear relationship exists between CU and discharge with the determination Co-efficient (R^2) equal to 0.903.

Table-1: Co-Efficient of Uniformity for Different Discharges

Discharge (cm^3/s)	CU (%)	Average value of CU (%)
257	32.50	43.01
342	41.73	
380	54.80	

Distribution Uniformity (DU)

The DU was calculated by equation 3 for different discharges is presented in Table- 2 which shows that the DU varied from 26.60% to 38.21% for discharges ranging from 257 to 380 cm³/s respectively. It has been also presented graphically shown in Figure-6. In Figure-6 it shows that the DU increases with the increase of discharge. Also a linear relationship exists between the DU and discharge with a determination co-efficient of 0.987.

Table-2: Distribution Uniformity (DU) for Different Discharges

Discharge (cm^3/s)	DU (%)	Average value of DU (%)
257	26.60	32.75
342	33.45	
380	38.21	

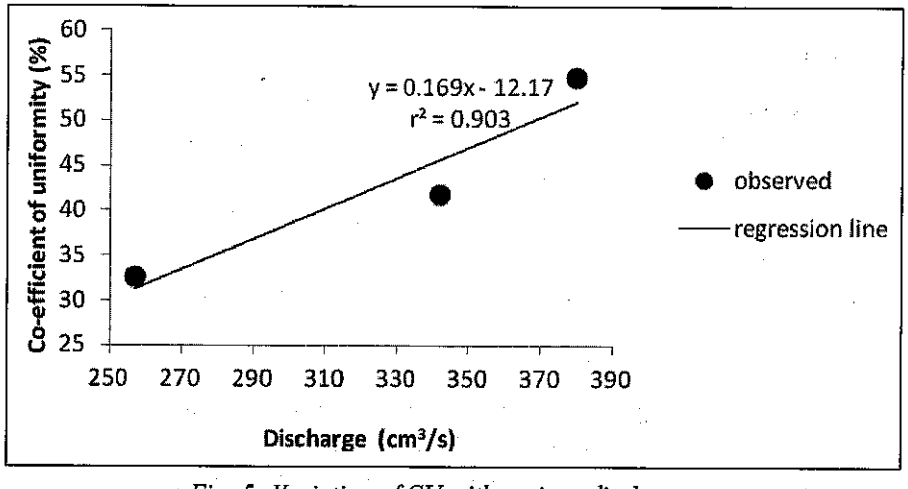

Fig.-5: Variation of CU with various discharges

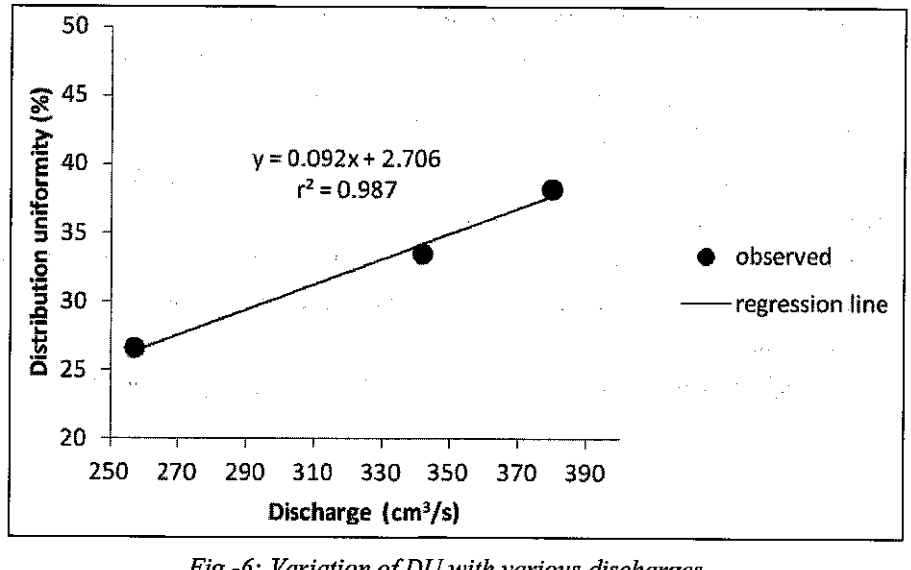

Fig.-6: Variation of DU with various discharges

Conclusions

The following conclusions are drawn from this study:

1. The Co-efficient of Uniformity (CU) varied from 32.50% to 54.80% with an average value of 43.01%.
2. The Distribution uniformity (DU) varied from 26.60% to 38.21% with an average value of 32.75%.
3. The Co-efficient of Uniformity (CU) and Distribution Uniformity (DU) showed a linear relationship with discharges.

Recommendations

1. For absolute uniform application the co-efficient of uniformity should be 100 percent.
2. For satisfactory consideration the uniformity co-efficient should be 85 percent or more.
3. Further study should be carried out for different conditions using twin nozzle rotating head sprinkler.
4. Wind speed was not considered under the study but it should be incorporated for better.

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Farmers' Access to Agricultural Information in Bangladesh: A Micro-level Study in Two Villages of Bogra

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Abstract

The focus of the study was to know farmer's communication process to receive agriculture related information and to assess the extent of exposure of the farmers in agriculture related information. In all, one hundred farmers were purposively selected from two villages for conducting this survey. Among them, 18% were female. Two FGDs were also conducted to collect the information on various aspects of agriculture along with some of its extension services. Like typical Bangladeshi villages, the main occupation of the inhabitants of the villages was based on agriculture. Another interesting finding was that the villagers became aware of the fact that insects were not effectively killed by insecticides as they did not use the insecticides simultaneously in all the fields of the villages. For this reason, they felt the necessity of some kind of mutual understanding and co-operation among themselves. It was also found that the farmers were using the powerful electronic mass media only for their entertainment purposes. People of the villages were involved, to some extent, in cattle or poultry farming in the traditional ways as they were not well trained. The farmers reported that the cross breed cows were not profitable because they ate more, needed more care, were more disease prone and the cost of their fodder was also very high. So, they were not very much interested in rearing cross-breed cows. For seeds, they depended mainly on Bangladesh Agricultural Development Corporation (BADC) but regarding pesticides and fertilizers, they depended on private agribusiness entities. Only few villagers knew about the newly built union information centre. Farmers preferred to go to traders and dealers to agriculture officials for getting suggestions when they faced problems.

Introduction

Almost 80 percent people of Bangladesh live in the rural areas. Among them 54 percent are employed in agriculture and the rest in rural non-farm (RNF) sectors (World Bank, 2013). Agriculture accounts for one-third of the country's gross domestic product and employs over half of the country's workforce (BBS, 2008). Bangladesh is an agriculture-based country but updated information about agriculture is not available in the remote rural areas as the villagers

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have limited access to the print and electronic media. Therefore, ensuring timely and accurate dissemination of agricultural information to them is important.

At present, many agencies are developing and disseminating agriculture information ranging from land preparation, production techniques, disease prevention and post-harvest techniques. In spite of the ongoing efforts of the government, temporal lag in delivering information creates a gap in farmers' knowledge and thus affects their agricultural production (Katalyst, 2010).

Agricultural extension consists of the dissemination of useful and practical information related to agriculture, including improved seeds, fertilizers, pesticides, improved cultural practices and livestock and the practical application of useful knowledge to the farm and the household (http://www.afita.org/files/web_structure/20110126174028_862349/20110126174028_862349_11.pdf).

Without developing communication infrastructure, it is difficult to disseminate information to farmers at the village-level in Bangladesh. They are also dependent on the skills and capacity of the service providers to use, manage and maintain the technology effectively. Matching the most appropriate communication technology with people's needs and capabilities is a crucial task for ICT providers (Hasan Roshidul, 2009). In Bangladesh, most of the people are dependent on agriculture and disseminating modern information and new technology to them is a crying need today.

Department of Agricultural Extension (DAE) has a major role in agricultural development. It serves as a source of advice and assistance to the farmers to help them increasing their production and effective marketing. The access to agricultural information is accomplished by different extension methods/ media which may come under individual, group or mass contact. The mass contact includes both the electronic and print media which is expected to play an important role in technology transfer.

Mass media like television, radio, newspaper, magazines, etc. are being used as the tools of disseminating agricultural and rural development information in many countries of the world. They have the power of reaching audiences very fast. Through them, it is possible to inform people about the problems and potential of agriculture in Bangladesh. Farmers who have access to television, obtained information on improved farming practices through it (T. M. Shaikh, 2010).

Objectives

Keeping these in view the study was conducted based on the following objectives:

i) to know farmers communication process to receive agriculture related information; and
ii) to assess the extent of exposure of the farmers to agriculture related information.

Methodology

The study was conducted during January 2012 to July 2012. Two selected villages of Shahjahanpur and Nandigram upazila under Bogra district were selected purposively. The number of sampling population was 50 in each village and all together turned into 100. Firstly, researchers prepared a list of 300 farmers whose main occupation was farming. The sample was drawn from this population by applying random sampling.

Data were collected by using both qualitative and quantitative methods. Under the quantitative method, data were collected using both closed and open-ended questionnaire at the household level from each village. To know the opinion of farmers regarding communication, Focus Group Discussion (FGD) was conducted with the help of a guideline. The inclusion criterion of information was direct or indirect dependency on agricultural activities. FGDs were done among two groups of farmers to collect information on agricultural activities and some of the extension services. Some related information was collected from the Upazila and Union Parishad offices. Data were processed using Microsoft Office Excel package.

Results and Discussions

General Information of the Village

The village Dohar, under Nandigram Upazila is situated about 12 km south-west and Goynakuri is situated about 8 km from Bogra town. The area of Dohar is about one sq km, and that of Goynakuri is about two sq km. The household number of Dohar is about 300 and that of Goynakuri is about 490. Distance of villages from upazila (Sub-District) headquarter are about 3 km and 10 km respectively. The respondents of Dohar compared to Goynakuri travel long distances from their villages to upazila offices to access government services and information.

Educational Status of the Farmers

The literacy rate was found to be excellent (76%) among the respondents of Dohar, whereas it was 66% in Goynakuri. The rate is low in Goynakuri than Dohar because of having less access to education. But both literacy rate is higher than the national literacy rate of 57.1% (BBS, 10). Most of the people of selected villages have basic education. Among the respondents of both Dohar and Goynakuri about 8% farmers completed their graduation. The details of educational qualification of the respondents are given in table-1.

Table-1: Educational Qualification of the Respondents

Educational qualification	Percentage of farmers (%)	
	Dohar	Goynakuri
Illiterate	2	08
Can sign only	22	28
Primary education	20	16
Junior Secondary	36	20
Secondary	04	16
Higher Secondary	08	04
Graduate	08	08
Total	**100**	**100**

Farmers' Personal Communication Scenario

An attempt was made to know how farmers communicate with others when they need any information regarding agricultural production. The sources of information were Upazila Agriculture Extension Office, NGO officials, Dealers/Traders (Input Suppliers), neighboring farmers and friends (Table-2).

Table-2: Source of Information for Rural Farmers

Source of Information	Frequency of communication (%)					
	Never		Regular		Occasional	
	D	G	D	G	D	G
Upazila Agriculture Extension Office	50	58	22	12	28	30
NGO officials	44	14	32	20	24	20
Dealer/Traders (Input Suppliers)	12	08	62	32	26	24
Neighboring Farmers and Friends	08	10	54	44	38	20

D= Dohar, G= Goynakuri

According to the respondents, only 22% of the respondents of Dohar and and 12% of Goynakuri regularly communicated with sub-assistant agriculture officers for taking advices related to agriculture production. If it is important to note that 50% of the farmers in Dohar and 58% of Goynakuri never communicated with these Government employees due to:

- Less awareness about the services.
- Lack of confidence on the agricultural officers.
- Lack of cordial behavior by the officers on providing their services.

A major portion of the farmers (62% and 32% respectively) regularly communicated with the persons involved in inputs supply whereas 26% of Dohar and 24% of Goynakuri communicated with the dealer/ traders of inputs occasionally. Farmers preferred to share their problems with their neighboring farmers and friends regularly (54% and 44% respectively) when they faced any problem. They communicated with other farmers occasionally (38% and 20% respectively). NGO officials were also communicated by the villagers for getting agricultural information.

Farmers Access to Information through Group Communication

Farmers of selected villages received information of agricultural production through different group communication programmes. Types of communication were farmer's meeting, visiting demonstration plots, farmer's field and training. Fig.-1 shows how they were using those programmes to get information.

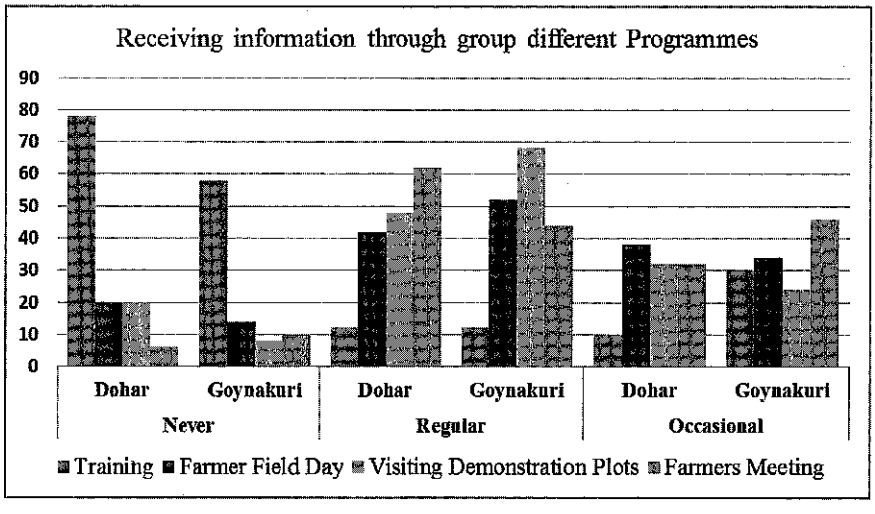

Fig.-1: Receiving Information through Group Communication in Different Programmes

It was found that 78% Farmers of Dohar and 58% of Goynakuri didn't get opportunities to participate in any training programmes. Only 12% of them participated in regular training programmes and 10% and 30% respectively participated occasionally. Farmers' field day along with visiting demonstration plots and farmers meeting were popular with the farmers.

Farmers Access to Information through Using Print Media

Farmers were getting agricultural information through using different print media. Table-3 reflects how they were using those media to get information. Most of the people (58% of Dohar and 60% of Goynakuri) of the villagers were not used to reading newspaper and 64% of Dohar and 58% of Goynakuri never read any agricultural magazine. Only few (16% of Dohar and 12% of Goynakuri) of farmers said that they read newspapers regularly and about 33% of the

villagers read occasionally while only 12% of Dohar and 18% of Goynakuri read magazines regularly and 24 % and 40% of the respondents respectively read it occasionally. Farmers also read leaflets (26% of Dohar and 16% of Goynakuri regularly, 52% of Dohar and 50% of Goynakuri occasionally and 26% Dohar and 32% of Goynakuri didn't read leaflets).

Table-3: Information Received from Print Media

Media	Frequency of communication (%)					
	Never		Regular		Occasional	
	Dohar	Goynakuri	Dohar	Goynakuri	Dohar	Goynakuri
Newspaper	58	60	16	12	26	28
Agricultural Magazine	64	58	12	02	24	40
Poster and Festoon	12	18	52	38	36	34
Leaflet	26	32	26	16	48	52

Farmers Access to Information through Using Electronic Media

Electronic media were very attractive to the villagers. As we know the power and strength of media, they can change the lifestyle of people. In this study, it was found that villagers were using them for recreational purposes only. The use of electronic mass media, especially Television (TV) was found to be more prevalent in the selected villages. On the other hand, percentages of listening Radio were lower (32% of Dohar and 48% of Goynakuri never listened to radio and 48% and 26% of the farmers listened it occasionally). Only 20% and 26% of them listened to radio regularly. Broadcasting of no attractive programme on agriculture was the reason they mentioned. Table-4 shows the scenario of using electronic media of the respondents to get agricultural information.

Table-4: Percentage of Using Electronic Mass Media by the Interviewees

Media	Frequency of communication (%)					
	Never		Regular		Occasional	
	Dohar	Goynakuri	Dohar	Goynakuri	Dohar	Goynakuri
Television	12	16	62	44	26	40
Radio	32	48	20	26	48	26
Mobile	16	28	76	68	08	04
Information Center	92	88	0	02	08	10
Internet	96	100	0	0	04	0

Mobile phone is playing an important role now a days to disseminate information and the respondents also mentioned that they used it regularly (76% of Dohar and 68% of Goynakuri) for getting information. Sometimes, they met agriculture officials or traders when they faced problems. Most of them were not aware about union information centre (90%) and nearly all

of them (98%) didn't use the Internet for receiving information regarding agriculture. In the village Dohar, a few people (4%) used the Internet occasionally.

Impact/ Importance of Getting Agricultural Information for Rural Farmers

Seeds

Most of the farmers (about 70%) of the village Dohar used self-cultivated seeds. On the other hand, only 52% farmers of Goynakuri did the same. Respondents told that they used to buy the seeds of Bangladesh Agricultural Development Corporation (BADC) and the quality of the seeds of BADC was mentioned as very good. A significant number of respondents communicated with dealer/ traders of seeds regarding selecting the seeds.

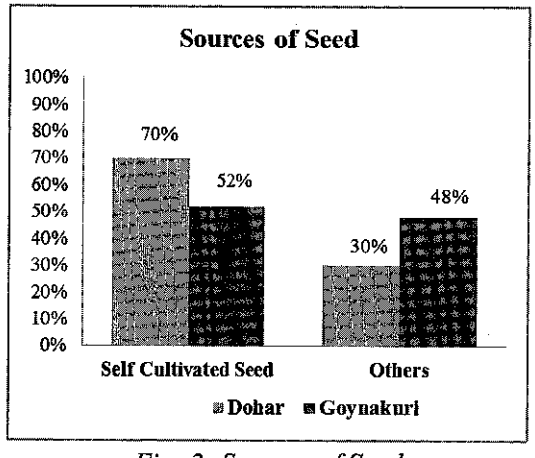

Fig.-2: Sources of Seed

Fertilizers

Majority (about 85% of Dohar and 88% of Goynakuri) of the farmers of both villages told that they bought fertilizers from govt. approved dealers. Most commonly used fertilizers were Urea, TSP, DAP, MOP, Gypsum, Zinc etc. Among the fertilizers, DAP was most expensive and the quality was reported as good.

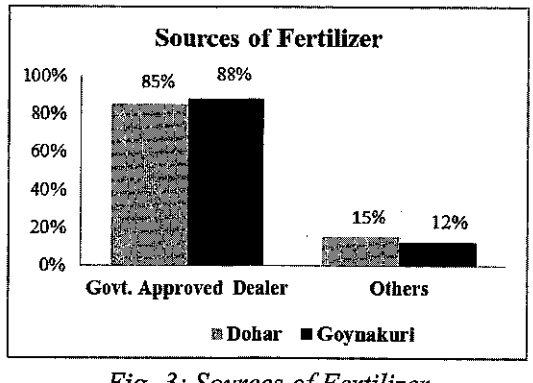

Fig.-3: Sources of Fertilizer

No incidence of crisis or scarcity of fertilizers within the last 2-3 years was reported. There was neither any awareness programme regarding detrimental effects of excessive use of chemical fertilizers nor any advocacy for using organic fertilizers in the villages from either Govt. or NGO side. They used cow dung for saving their land and sometimes they used *dolochun*.

Pesticides

Most of the pesticides were collected from the nearest market. The farmers mentioned that sometimes insects were not effectively killed by insecticides as they did not use the insecticides simultaneously in all of the fields of the same area. For this reason, they felt the necessity of some kind of mutual understanding and co-operation among themselves. Again, a few awareness programme regarding the harmful effects of using pesticides in excessive dose or frequency was reported. Farmers claimed the unavailability of natural pest control system in their area and for that reason they could not use that less expensive products.

Livestock

The people of both the villages were involved to some extent in cattle or poultry farming in traditional ways but they were not well trained. They found that the cross breed cows were not profitable because they needed more foods and more care, were more disease prone and the cost of their fodder was also very high. So, they were not very much interested in rearing cross-breed cows. On the whole, the following bottlenecks were identified in this sub-sector:

- high price of fodder,
- lack of adequate veterinary treatment facilities,
- fluctuating price of milk,
- lack of proper training and awareness,
- lack of financing,
- lack of insurance facilities,
- lack of information.

Only few commercial poultry farm were seen in the villages during survey, although ducks or chicken were noticed in almost every household. The following bottlenecks were reported by the villagers in this sub-sector:

- high price of poultry feed,
- high incidence of diseases,
- lack of transport facilities,
- lack of financing,
- lack of proper training and awareness,
- lack of information.

Conclusions and Recommendations

The government of Bangladesh has introduced extension services and transferring agricultural technology from research station to the rural people of Bangladesh. Thus farmers are being made aware of new technology which assists in boosting up agricultural productivity in the country. This report doesn't represent the whole scenario of the farmers' communication but it is expected that the provided information will be useful for future extension activities in the country. We also recommend the following on the basis of the findings:

- Sub-assistant agricultural officers are trying their best to help farmers but their collaboration with the villagers needs to be improved.
- Programmes should be taken by the Govt. and / or NGOs to encourage the villagers to use organic fertilizers and environment friendly ways of pest controlling.
- Awareness raising programmes should be taken in cross-breed livestock farming along with poultry and fisheries and proper training should be arranged.
- Union information centres can play a vital role to disseminate necessary information to rural farmers.
- Mass media, especially electronic media, has the potential role to reach large audiences at low cost. With the increasing availability of televisions, cell phones, and even computers, it is possible to use these methods in extension programmes.

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Livelihood Improvement of Tribal People through Microcredit: A Study in Selected Areas of Rajshahi District

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Abstract

The present study was undertaken aiming at analyzing the impact of micro credit on the livelihood pattern of the tribal people in selected areas of Rajshahi district. Four villages of Godagari Upazilla of Rajshahi district were selected purposively where the micro credit program for the tribal community was carried on. A total of 60 tribal respondents taking fifteen from each selected villages were chosen as sample of the study. The findings of the study showed that 67% of the respondents was engaged in agriculture, 25% was engaged in small trade and about 8% was engaged in rickshaw or van pulling. The average annual income and savings of the respondents was Tk.53830 and Tk.2838 respectively. The average credit received by the respondents was Tk.4800. Due to poor economic conditions the tribal respondents could not utilize 100 percent of their loaned money in productive purposes. Nevertheless after taking loan the respondents have been able to make change in their livelihood. The changes occurred in their income, expenditure and savings. The study showed that involvement in the micro credit program has brought about positive impact on the livelihood improvement of the respondents in the study areas. The problems identified by the respondents were such as high rate of interest, insufficiency of credit amount, more consuming negotiation period and dominance of non- tribal people over tribal people. It would be better to improve their livelihood pattern if the micro finance institutions could provide micro credit at an easy terms and conditions with lower interest rate especially for the tribal people.

Introduction

Bangladesh is an agro-based country and her economy is characterized by unfavorable per capita income and accentuating income disparity, high level of unemployment, low productivity and persisting high level of poverty and deprivation. The tribal people suffer more from these unfavorable indices than other segment of population in our country. There are various classes of tribal people in Bangladesh usually living in the hilly areas. The total tribal population of Bangladesh is estimated at about 1.41 million (BBS, 2007). There are more than

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30 different tribes in Bangladesh. Among them Chakma, Mog, Murong, Kuki, Lici, Khashia, Garo, Hajong, Koach, Shantal, Monipuri are significant. The tribal people occupy a significant place in Bangladesh and play an important role in production activities of agriculture sector. The term "*Adibashi*", or "indigenous people" is sometimes used to mean the people who are otherwise referred to as "tribal". The tribal people are in fact, the original inhabitants of the soil who are poor and hardly aware of their rights and privileges. Agriculture is now the only major means of living of this community. As they are illiterate and backward, they are weak to reap the benefit of modern technology from the delivery system. They also suffer from lack of sufficient capital to operate their IGAs for their livelihood. So the tribal people should be provided with adequate external finance like others.

Micro credit has been considered as a means of reducing poverty. It is also a means of enabling the poor to have easy access to undertaking economic activities. Given that the tribal people have little or no property or assets at all to offer as collateral which is required by formal banking system. Micro credit has responded to the predicament by offering collateral free loans. Micro credit program has been promoted to help the tribal poor take up self-employment on micro scale with a view to improving their living conditions. There is therefore, a huge gap between the need for credit of the tribal population and the availability of affordable credit lines for them. Ashrai is a local non-government organization (NGO) providing social and financial services to the tribal and very poor people in the greater Rajshahi region, the north-west part of the country. Tribal people have no access to other sources of microcredit in the study area. The organization is well known for its commitment towards poverty alleviation through provision of micro finance program for the tribal people. The tribal people are living in different parts of the country. They have their own language, culture and life style which are considered as important resources of our country. But this tribal community has been deprived politically, socially and economically. With a view to improving their socio economic conditions *Ashrai* has started its micro finance program particularly for the tribal community in greater Rajshahi. The present study was undertaken aiming at assessing the effectiveness of the microcredit program on the livelihood change of the tribal community.

Objectives of the Study

The major objectives of the study were:

i) to assess the socio-economic characteristics of the tribal community in the study areas;

ii) to investigate in to the availability, utilization and repayment of loan received by the tribal beneficiaries; and

iii) to examine the impact of credit on the livelihood of the tribal respondents.

Methodology

Godagari Upazilla of Rajshahi district was selected purposively first as micro finance program of *Ashrai* for the tribal people is carried on this area. Four villages namely Shialipara, Bot tala, Gopalpur and Modhumat were selected as the study areas. A draft list of the credit receiver was prepared with the help of the *Ashrai* personnel. A total of sixty respondents tribal beneficiaries taking fifteen from each selected villages were chosen as sample for the study. The simple random sampling technique was followed to select respondents. The required data were collected through direct interview with the help of pre-designed pretested interview schedule. The collected data were checked and monitored, tabulated and analyzed in order to achieve the objectives set for the study.

Findings

Distribution of the Respondents According to Different Age Group

The respondents were categorized into three different age group such as (i) having age from 18-35 years, (ii) age from 35-50 years and (iii) above 50 years of age. The table-1 revealed that the highest proportion of respondents (62%) belonged to the age group of 18- 35 years which is considered to be active age group, whereas about 33% of the respondent belonged to the age group of 35-50 years and only 5% of the respondent belonged to the age group of above 50 years.

Table-1: Distribution of Respondents According to Age Group

Age group (years)	Respondents Category			
	Agriculture	Small trade	Van/Rickshaw pulling	All
18-35	24 (64.86)	8 (53.34)	5 (62.50)	37 (61.67)
35-50	12 (32.43)	5 (33.33)	3 (37.50)	20 (33.33)
Above 50	1 (2.71)	2 (13.33)	-	3 (5.00)

Source: Field Survey, 2009-10, Figures in the parentheses indicate percentages

Literacy Status of the Respondents

The respondents were categorized into four groups based on their educational attainment such as (i) illiterate, (ii) able to sign only, (iii) up to primary level and (iv) secondary level. It was evident that about 22 percent of the respondents were found illiterate, 45 percent of the respondents were able to sign only, 25 percent of the respondents had the education up to primary level and only 8 percent of the respondents had the education at secondary level. No

one respondent was found having education above secondary level. The table also shows the educational status of the respondent according to their occupation. It was revealed that 37.5 percent of the respondents having profession of rickshaw pulling fall in the illiterate group followed by the respondent of agriculture profession about 22 percent and respondent of small trader13 percent. Majority of the respondents of small trading and rickshaw pulling category were able to sign only representing 67 percent and 62 percent respectively. As against this about 12 percent respondents of agriculture category were able to sign only. There found no respondent of rickshaw pulling category having profession. About 35 percent of the respondents of agriculture profession had education up to primary level followed by 13 percent respondent of small trading profession. Only 10 percent of the respondents of agriculture profession and that of six percent of small trading profession had education up to secondary level.

Farm size of the Respondents

Considering all categories of respondent, it reveals that the average farm size of the respondents under legal status was only 0.65 acre and that was 0.81 acre under defacto status. Among the three categories of respondents the highest farm size was 0.84 acre for the respondents of agriculture category. The farm size was lowest (0.65 acre) for the respondents of small trade category (Table-2).

Table-2: Average Farm Size of the Respondent Households (In acres)

Type of land	IGAs			
	Agriculture	Small trade	Van/Rickshaw pulling	All
(1) Cultivable land	0.75	0.50	0.25	0.50
(2) Land rented out	0	0	0	0
(3) Land rented in	0.20	0.05	0.06	0.103
(4) Mortgaged in	0.18	0.25	0.20	0.21
(5) Mortgaged out	0	0	0	0
(6) Pond	0.03	0.06	0.20	0.096
(7) Homestead	0.06	0.09	0.03	0.07
Total	1.22	0.95	0.74	0.97
(8) Average land under legal status (1+2+5+6+7)	0.84	0.65	0.48	0.65
(9) Average land under defector status (1+3+4)	1.13	0.80	0.51	0.81

Source: Field Survey, 2009-10

Occupational Status of the Respondents

Occupation is one of the important attributes of socio economic characteristics. In the study areas, most of the respondents were farmers but besides farming they were engaged in various IGA's after having loan from *ASHRAI*. The sampled respondents were categorized according to the occupational status. It was evident that agriculture was the occupation of the majority of the tribal respondents 67 percent, small trading was the occupation of 25 percent respondents and rickshaw/van pulling was main occupation of 13 percent respondents.

Adequacy of Loan as Required by the Respondents

It was evident from the Table-3 that the tribal respondents received 85% of their required amount of loan from the *Ashrai* NGO. The respondents of agriculture category received the highest amount of loan Tk. 5100 (89.47% of the amount applied for) and the respondent of the rickshaw pulling category received the lowest amount of loan Tk. 3600 (80% of the amount applied for).

Table-3: Adequacy of Loan as Required by the Respondents

Respondent category	Average amount applied for (Tk.)	Average amount received (Tk.)	Loan received as % of amount applied
Agriculture	5700	5100	89.47
Small trade	6600	5700	86.37
Van/Rickshaw pulling	4500	3600	80.00
All	5600	4800	85.28

Source: Field Survey, 2009-10

Utilization of Borrowed Money

Table-4 showed that 41.25% of the loaned money was spent for capital expenditure i.e. purchasing of the major input for operating their IGAs. About 30% of the loaned money was spent to meet the expense of their daily needs such as food consumption, treatment cost, education cost for the children etc. The respondent spent17.70% of their loaned money for business expenditure and spent 10.8% of the loaned money for farming as every category of respondent had some land for cultivation.

Table-4: Utilization of Borrowed Money

Type of expenditure	Average amount (Tk.)	Percentage (%)
Capital Expenditure	1980	41.25
Expenditure on farming	520	10.84
Family expenditure	1450	30.21
Business expenditure	850	17.71
All	4800	100.00

Source: Field Survey, 2009-10

Repayment of Credit

Loaned money is to be repaid with an interest rate of 12.5 percent through 11 monthly equal installments starting from the next week of the loan received. Table-5 shows that 100 per cent loan has been repaid by all categories of respondent. Overall loan recovery percentage was fully satisfactory due to strong monitoring of the "*Ashrai*" personnel.

Table-5: Repayment of Credit by the Borrower

Respondent Category	Average amount paid				Percentage of total repayment
	Installment (no.)	Principal (Tk.)	Interest (Tk.)	Total (Tk.)	
Agriculture	11	5100	637.5	5737.5	100
Small trade	11	5700	712.5	6412.5	100
Van/Rickshaw pulling	11	3600	450	4050	100

Source: Field Survey, 2009-10

Factors Affecting Timely Loan Repayment

The respondents were asked regarding the factors which have inspired them to repay the loan on time. Most of the respondent (87%) opined that they had repaid their loan timely with the hope of getting more credit in the future. About 75% of the respondents were observed to have repaid their loan on time due to proper supervision made by the field level staff. About 62% of the respondents opined that they repaid their loan due to self-consciousness and about 58% of the respondents expressed that they had been able to repay their loan for getting benefit from their IGAs (Table-6).

Table-6: Factors Affecting Timely Loan Repayment

Factors	No. of respondents	Percentage
To get further loan	52	86.67
Proper supervision by the staff	45	75
Pressure by the other members	35	58.34
Self-consciousness	37	61.67
Gross benefit received from the project activities	30	50

Note: More than one answer were given

Changes in Household Annual Income

Average annual income of the respondent according to their profession was calculated sequentially and it was Tk.53062, 56748 and Tk.51690 for the agriculture, small traders and rickshaw puller categories (Table-7). It is evident that average income of the respondents from all possible sources have been increased after joining the *ASHRAI*. Before joining the

ASHRAI, average annual income was Tk. 43128.34, which rose to Tk. 53830 showing 24.82 percent income increase in the study area (Table-7).

Table-7: Changes in Household Annual Income

IGAs	Income before (Tk.)	Income after (Tk.)	Net Change	
			(Tk.)	%
Agriculture	41675	53052	11377	27.30
Small trade	43738	56748	13010	29.75
Van/Rickshaw pulling	43972	51690	7718	17.56
All	43128.34	53830	10701.66	24.82

Source: Field Survey, 2009-10

Changes in Annual Savings of the Respondent Household

It is found from table-8 that average savings of the respondents was Tk. 842 before joining and it was enhanced to Tk. 20837.66 after joining the *ASHRAI* program. Taking all categories together it is seen of the respondent increased by 237.02 percent after joining *ASHRAI* credit program. Changes in savings was registered highest for the respondent of small trade category (336%) followed by the respondents of van pulling category (241%) and the respondent of agriculture category (91%).

Table-8: Changes in Household Annual Savings of the Respondents

IGAs	Before			After			Change in Savings	
	Av. income (Tk.)	Av. Expenditure (Tk.)	Savings (Tk.)	Average income (Tk.)	Average Expenditure (Tk.)	Savings (Tk.)	Net Change	Percent change
Agriculture	41675	40735	940	53052	51255	1797	857	91.18
Small trade	43738	42360	1378	56748	50742	6006	4628	335.56
Van pulling	43972	43764	208	51690	50980	710	502	241.35
Total	43128.34	42286.34	842	53830	50992.34	2837.66	1995.66	237.02

Source: Field Survey, 2009-10

Changes in Land Ownership

The land ownership pattern of the borrower households before and after enrollment in *ASHRAI* is shown in table-9. It is seen from the table that the percentage increase in the ownership of land of the respondents (considering all respondents) after joining *ASHRAI* was 22.64 percent.

It is evident that highest increases in the ownership of land were registered 27.45 percent for the respondents of small trade category. The respondents of rickshaw pulling category had been able to increase their land (20%) in their total land holding after joining the *Ashrai* program.

Table-9: Changes in Land Ownership

Respondent category	Land before (acre)	Land after (acre)	Land purchased during the year	Change in own land %
Agriculture	0.69	0.84	0.15	21.73
Small trade	0.51	0. 65	0.14	27.45
Van/Rickshaw pulling	0.40	0.48	0.08	20.00
Total	0.53	0.65	0.12	22.64

Source: Field Survey, 2009-10

Changes in Sanitation Condition

Availability of sanitation facilities is a major concern for reducing rapid spread of communicable diseases like diarrhea, typhoid, gastro-intestinal infection, etc. It is evident that about 3% of the respondents used sanitary latrine but before joining the micro credit program no respondent used sanitary latrine. About 88% of the respondent used half sanitary latrine after involvement in micro credit program as against 28% of the respondent used same type of latrine before the program. It can be concluded that after joining the micro credit program the respondents became more health conscious.

Changes in the Source of Drinking Water

This study showed that sent percent respondent households used tube-well water for their daily work. Using tube well water had increased cent percent after their involvement in *ASHRAI* program implying that the health consciousness of the respondents improved. It is also evident that majority of the respondent households used water from their own tube well and only 30% of the tribal respondents used water from their neighbors tube-well for their daily works.

Changes in the Livelihood Pattern of the Micro credit beneficiaries

Microcredit provided by *Ashrai* has made some positive impact on the livelihood of the tribal beneficiaries leading to the improvement of their socio-economic status. Changes in the different socio-economic characteristics occurred due to proper loan use considerably as well as repayment of loan. Scaling of measures was expressed by the respondents in terms of increase and no change. After joining the micro credit program about 87% of the total respondents opined that there has been a positive change in education of the family members

as the respondent had been able to send their children to school. After joining the program, family income increased 93.34% and thereby savings 73.33% were quite evident as discussed. Other characteristics such as GO- NGO involvement, employment, consumption expenditure, and household savings, and social relations, involvement in social and political organization, women participation, access to health facilities, recreation and access to electricity have increased (Table-10).

Table -10: Socioeconomic Changes Occurred Among the Respondents

Heads	Increase	No Change	Total
Family income	56 (93.34)	4 (6.66)	60 (100)
GO and NGO organizational involvement	51 (85)	9 (15)	60 (100)
Involvement in social and political organization	41 (69.34)	19 (31.66)	60 (100)
Household savings	44 (73.33)	16 (26.67)	60 (100)
Employment	48 (80)	12 (20)	60 (100)
Education of family	52 (86.67)	8 (13.33)	60 (100)
Consumption expenditure	54 (90)	6 (10)	60 (100)
Access to Health Facilities	40 (66.67)	20 (33.33)	60 (100)
Recreation	54 (90)	6 (10)	60 (100)
Social Relation	42 (70)	18 (30)	60 (100)
Women Participation	51 (85)	9 (15)	60 (100)
Access to Electricity	40 (66.67)	20 (33.33)	60 (100)

Source: Field Survey, 2009-10, Figures in parentheses indicate percentages.

Constraints Faced by the Borrowers

High Rate of Interest

High rate of interest was one of the problems in taking loan from *ASHRAI*. In the study areas, about 94% of the respondents of agriculture category expressed it as major problem in taking loan from *ASHRAI* followed by 80% of small trade and 63% of Rickshaw pulling category respondents.

Insufficiency of Credit

About 81% of borrowers of agriculture category, 86% of small trading category and 87% of rickshaw pulling category complained that the amount of credit provided by *ASHRAI* was not sufficient for operating their IGAs.

Not getting credit in time

A major portion of the respondents reported that they did not get loan at the time of their need. About 48.65%, 46.67% and 75% of the respondents from agriculture, small trade and rickshaw/van pulling category respectively reported that they did not get loan timely.

Early starting of loan repayment period

Most of the respondents reported that it was very difficult for them to start the repayment the loan just next week of receiving the credit because it was very difficult to get return from any investment so quickly. Major portion of the borrowers respondent in the study areas were facing this problem.

Dominancy of non-tribal people over tribal people

Most of the respondents reported that as they are tribal people, they are dominated by the general people. Taking all categories of respondent together it was observed that about 83% tribal borrowers were facing this kind of problem in the study area.

Conclusion and Policy Implications

Most of the tribal people in the study areas lived below subsistence level. But after joining the microfinance program of *Ashrai*, the respondents have been able to increase their income and savings. The overall socio-economic conditions, awareness about rights, involvement in socio-political organization, access to health facilities, improved housing conditions, sources of drinking water, sanitation were remarkably increased in the study areas. The tribal beneficiaries became more conscious about health and hygiene after joining the micro credit program. After receiving the microcredit the respondent households had been able to use drinking water from tube well and sanitary latrine that led to decrease the incidence of many contaminated diseases. The respondents have been able to save money after joining the micro

credit program of *Ashrai*. The findings show that the respondents have been able to increase their farm size through purchasing of new cultivable land. The repayment of loaned money by the borrower was fully satisfactory i.e., 100%. The respondent however used the loaned money in unproductive purposes due to the inadequate amount of the loan provided by that NGO. The government and NGO should provide more credit to the tribal people at an easy terms and conditions for the livelihood improvement of them. Government can allocate special fund for health and education for the children of the tribal people and employment of the rural people in Bangladesh. More schools and community health clinic can be established for the betterment of the tribal people as a whole. Social safety-net programme should be expanded for the tribal people to uplift their livelihood and ensuring food security of this neglected segment of population. Finally, government should undertake comprehensive and pragmatic programs with GO-NGOs collaboration particularly for the improvement of the livelihood of the tribal people.

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Screening of Antibacterial Activities of Ethanol Extract of Fenugreek leaf (*Trigonella foenum*)

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Abstract

The aim of the study was to screen the medicinal and antibacterial activities of ethanol extracts of the Fenugreek (Trigonella foenum L.) spices available in Bangladesh. Crude extract of the spices with ethanol were screened for antibacterial activities against three Gram negative bacteria i.e. Escherichia coli, Salmonella spp, Shigella spp and gram-positive Staphylococcus aurous. In vitro antibacterial activity was performed by agar well diffusion method. Ethanol extract of Fenugreek revealed an elevated antimicrobial activity against Escherichia coli compared to other bacteria. The results obtained in the present study suggests that the ethanol extract of Trigonella foenum Linn revealed a significant scope to develop a novel broad spectrum of antibacterial herbal formulation.

Introduction

Nature has been a source of medicinal plants for thousands of years since the beginning of man. It is apparent from historical records that most of the early peoples like Assyrians, Babylonians, Egyptians and ancient Hebrew were familiar with the medicinal properties of many medicinal plants. As far as available records it appears that Babylonians (about 3000Bc) were aware of a large number of medicinal plants and their properties. Some of the plants were used by them are in use in almost the same manner and for the same proposes (Ghani, 1998).

Over the past twenty years, interest in medicinal plants has grown enormously from the use of herbal products as natural cosmetics and for self medication by the general people for their biological nature. Beyond this pharmaceutical approach to plants, there is an increasing tendency to utilize herbal products to supplement the diet mainly with the intention of improving quality of life (Maffei, 2003).

According to WHO, more than 80% of the world's population relies on plant based herbal medicines for their primary health care needs (Shanmugasundaram, 2005). In industrially developed countries, almost 35% of drug contains active principle of natural origin and composition of medicinal plants is increasing .The use of traditional medicine is also widespread in India (Jeyachandran and Mahesh, 2007). The practice of traditional medicine in China is also firmly established with more than five thousand kinds of Chinese medicinal herbs.

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From a survey in different villages of Bangladesh, it has been observed that if the people suffer from illness approximately 14% of them go to the qualified allopathic doctors, 29% contact unqualified village doctors, 10% contact mullah, 29% approach quack and 19% contact homeopaths (Ghani, 1988). It has also been reported that till now only 30% of the entire population has been brought under primary health care. Twenty percent of the population of our country has access to the medicines and rest 75-80% of the rural population still receives health care services form the indigenous traditional ethno medicine practitioners.

In Bangladesh more than 250 of such medicinal plants are in common use in the preparation of traditional medicine (Yusuf *et al.*, 1994). The suitable weather and fertile soil of Bangladesh made a great source of medicinal plants. About five thousand herbs, trees, aromatic and aquatic plants are scattered throughout the forests, jungles, hills, crop fields, plain fields, roadsides, gardens, marshy lands and watery places of Bangladesh. These indigenous plants are reservoirs of various metabolites and provide unlimited source of important biochemical that have diverse biological properties These medicinal plants contain steroids, alkaloids, tannins, saponins, glycosides, acetogenin and resin are most useful medicinal agents and they serve as important therapeutic agents as well as imported raw materials for the manufacture of traditional and modern medicines. Substantial amount of foreign exchange can be earned by exporting medicinal plants to other countries (Ghani, 1988).

Trigonella feonum graecum L. commonly known as Fenugreek belongs to the family Leguminous which is an annual, herbaceous and aromatic plant. Fenugreek has originated from Indian subcontinent & Eastern Mediterranean. It is widely distributed in Europe and Asia. The major seed producing country are India, Ethiopia, and Egypt. The seeds of this plant are used as a spice and the leaves are edible and used as a vegetable in many parts of India. In India the seeds are used in curries and dyes and medicine and young seedlings are often eaten as vegetables.

The ethanoloic extract of the plant showed antibacterial and antifungal activity. Preparations of normal and germinated seed have been found to produce hypoglycemic effect in diabetic patients. Seed also produces strong hypoglycemic effect and significantly reduces total cholesterol, LDL, VLDL, cholesterol and triglycerides. Leaves are useful as mild aperients (Chjeveliar, 1996). It restores the activity of enzyme of carbohydrate and lipid metabolism. It has anti-inflammatory, antiviral and anti-tumor activity. It stops stomach and intestinal pain. Fenugreek seed is reported to have anti-diabetic, anti-fertility, anticancer, anti-microbial, anti-parasitic, lactation stimulant and hypocholesterolaemic effects (Al-Habori and Raman, 2002). In Ayurveda, both fenugreek seed and leaves are used to prepare extracts or powder for medicinal use (Basch *et al.*, 2003).

Objectives

Many researchers have shown the antibacterial and antioxidant activities of fenugreek seeds. However a very little known about the chemical composition of these plants. A detailed study

on the antibacterial and antioxidant activities of the fenugreek leaves has not been so far carried. Therefore, this plant has been taken into consideration with a keen interest to investigate the following objectives:

i) Isolation and characterization of the extract from *Triogenella foenum graceum*; and
ii) Investigation of antibacterial activity of the extract.

Materials and Methods

Plant Material

Fresh and healthy leaves of *T. foenum graecum* were obtained from Kushtia Municipal Market in the month of April during the year 2006. The leaves were washed thoroughly in distilled water and the surface water was removed by air drying under shade. The leaves were subsequently dried in a hot air oven at 40°C for 48 h, powdered and used for extraction.

Test Microorganisms

The test organisms used in this study were gram-negative i.e. *Escherichia coli, Salmonella spp, Shigella spp* and gram-positive *Staphylococcus aureus* to determine the antibacterial effect of the extract. The bacterial cultures were maintained on nutrient agar medium.

Preparation of Solvent Extract

10 gm of the fenugreek leaf powder was weighted with electric balance and 50 ml each of the solvent (ethanol) was added in each conical flask. The powder was extracted separately with ethanol. The samples with solvent were placed in water bath shaker for 24 hours. The extract was filtered with sterile whatman filter paper into a clean conical flask. Second extraction was carried out with same amount of solvent and filtered. The extracts were later pooled and transferred into the sample holder of the rotary flash evaporator for evaporation of the solvents. The evaporated extract so obtained was weighed and preserved at 4°C in airtight bottle until further use.

Inoculums Preparation

Ten ml of distilled water was taken into the screw cap tube and pure colony of freshly cultured bacteria was added into the tube and vortex was done. The OD (optical density) was measured with the colorimeter and microbial population was confirmed to be within in 10^7 ml-1 to 10^8 ml-1. This suspension was used as inoculums.

Preparation of Disc

The disc paper was soaked with each concentration of extracts and placed at room temperature for air dry for 15 hours. Then dried disc paper was placed in oven for 1 hour at 37°C. After completion of the oven dry, the disc paper was taken into vial and it was ready for antimicrobial activity.

Antibacterial Assay

In vitro antibacterial activities of the test samples were carried out by disc diffusion method (Bauer *et al.*, 1996; Barry, 1980). In the disc diffusion method, nutrient agar (HiMedia, Mumbai) was used as culture media and the discs were placed aseptically over the bacterial culture on nutrient agar plates and incubated at 37°C for 24 hours. After incubation for 24 hours, the zone of inhibition around the discs was measured by millimeter scale. Discs were soaked with each treatment and control was assayed on duplicate agar medium plate for *Escherichia coli, Salmonella spp*, *Shigella spp* and *Staphylococcus aureus*. The diameter of zone of inhibition (mean of two replicates ±SD) as indicated by clear area which was devoid for growth of microbes was measured to determine the antibacterial activity. The experiment was replicated two times to confirm the reproducible results. Sterile, blank paper discs soaked with only sterile ethanol served as negative control each time. Standard Nalidixic acid (30 µg/disc), Erythromycin (15 µg/disc) and Ciprofloxacin (5µg/disc) were used as positive control for comparison of the antibacterial activity. Minimum Inhibitory Concentration (MIC) value of the extracts of the Fenugreek was determined in present study following the serial dilution technique according to Reiner, (1982).

Results and Discussions

The leaf powder of the fenugreek showed antimicrobial activity against all test microorganisms such as *Escheria coli, Salmonella sp, Shigella sp & Staphylococcus aureus*. The ethanol extract of fenugreek leaf showed highest inhibitory activity against E.coli compared to other organisms tested. In addition, the ethanol extract of the fenugreek leaf were also sensitive to the *Salmonella sp, Shigella sp & Staphylococcus aurous*. The following table represents the antibacterial activity & minimum inhibitory concentration of ethanol extract of fenugreek leaf against the above mentioned test organism.

Table-1: Comparison of Antibacterial Activity & Minimum Inhibitory Concentration against Test Organism at Different Concentration by Using Ethanol Extract of Fenugreek

Name of test organism	Ethanol extract of fenugreek leaf at different concentration (µg/l)									Positive Control (mm)			Negative control
	512 µg/l	256 µg/l	128 µg/l	64 µg/l	32 µg/l	16 µg/l	8 µg/l	4 µg/l	2 µg/l	NA (30)	CIP (5)	E (15)	
E coli.	15(-)	14(-)	13(-)	12(-)	11(-)	+	+	+	+	15(-)	23(-)	13(-)	+
Salmonella sp	+	+	+	+	+	+	10(-)	11(-)	12(-)	12(-)	18(-)	10(-)	+
Shigella sp.	10(-)	9(-)	16(-)	+	+	+	+	+	+	12(-)	18(-)	15(-)	+
Staphylococcus aureus	+	+	+	12(-)	13(-)	14(-)		+	+	15(-)	18(-)	20(-)	+

+= No zone of inhibition, - = Zone of inhibition

From Table-1 it was observed that ethanol extract of fenugreek leaf produced zone of inhibition ranged from 11mm-15 mm at 32 µg/l, 64 µg/l, 128 µg/l, 256 µg/l & 512 µg/l concentrations

against *E.coli*. Similarly, the ethanol extract of fenugreek leaf produced zone of inhibition ranged from 10mm-12 mm at 2 µg/l, 4 µg/l & 8 µg/l concentration against *Salmonella sp*. Different zone of inhibition (10mm, 9mm & 16 mm) was also found against *Shigella sp* at different concentration (512 µg/l, 256 µg/l, 128µg/l) respectively from fenugreek leaf ethanol extract. The zone of inhibition was also found ranged 12mm-14 mm against *Staphylococcus aureus* at different concentration (64 µg/l, 32 µg/l & 16µg/l) from ethanol extract of fenugreek leaf. Negative control i.e., disc containing only ethanol solvent showed no resistance against the entire test organisms. All the positive inhibitions showed antibacterial activity against test bacteria.

Microorganisms are the concealed enemies to the mankind. They are small but cause a very profound damage in human body as well as other living organisms. The agents, which have the capacity to kill the microbes or arrest multiplication, are called the antimicrobial agents or drugs. There are a lot of antimicrobial drugs of which some are discovered or established and some are hidden in the nature. Hence, the last decade witnessed an increase in the investigations on plants as a source of human disease management (Aiyelagabe OO, 2001; Prashanth D. *et al.*, 2001; Mounishwamy V *et al.*, 2002; Woldemichael GM *et al.*, 2003) and more natural antimicrobials have driven scientists to investigate the effectiveness of inhibitory compounds such as extracts from plants (Nasar-Abbas, 2004).There are several reports of antibiotics resistance of human pathogens to available antibiotics (Ganguly A,2004; Di Martino P, 2002). Bimolecular of plant origin appear to be one of the alternatives for the control of these antibiotic resistant human pathogens.

The main objective of this work was to increase the utilization of biomass from spices in order to isolate new biologically active compounds. Spices are recognized as having food preserving possibilities by the Egyptians some 3,000 years ago. The antibacterial factors are found in the essential oils of the spices. Gram positive bacteria were more resistant to the essential oils of the spices than gram negative bacteria. This study deals with three gram negative bacterial and one gram positive bacterial strains. In the present work, the antibiotic potential of the ethanol extracts of the Fenugreek leaf has been determined against *Escheria coli, Salmonella sp, Shigella sp & Staphylococcus aurous*. The extracts of Fenugreek have been reported to possess antibacterial activity. Blank disc produced no zone of inhibition of *Escheria coli, Salmonella sp, Shigella sp & Staphylococcus aurous* indicating that the solvents (ethanol) did not possess any antimicrobial effect on the pathogen. MIC value was also determined against all bacteria.

Conclusions

In the study it was found that the ethanol extract of fenugreek leaf showed highest inhibition zone against *Escheria coli* compared to other test organism. This ethanol extract also showed better inhibition zone against the rest three organisms. However the minimum inhibitory concentration was found even at low concentration. This may be happen due to impurities of the solvent or disc paper was not completely soaked. But it can be concluded that the ethanol

extract of fenugreek leaf may be used as a good source of herbal medicine as we got from the findings. This study paves the way for further attention and research to identify the active compounds responsible for the plant biological activity. Further studies should be undertaken to elucidate the exact mechanism of action by which extracts exert their antimicrobial effect.

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Socio-economic Impact of using Farm Machineries on Changing Livelihood Pattern of the Agricultural Women Laborer in Northern Bangladesh

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Abstract

The present study is an attempt to analyze various socio-economic aspects of agricultural women labors under modern technology including changes in livelihood pattern. A Total of 60 sample women laborer were purposively selected from three villages namely Rampura, Astosopur and Shitalgari under Rangpur District. The impact of the study was examined in terms of economic and social gains accrued by the women and their family activities. The finding is that the average annual income per respondent household has increased to a great extent. The expenditure as well as savings pattern indicated a positive attitude towards life improvement and the standard of living because of women's contribution in family income. There occurred substantial change in the occupation of the respondents after adoption of modern technologies. Their working days have increased from 204 days to 280 days in a year. The housing condition, health and sanitary measures, pure drinking water facilities have improved. It was clearly visible that using modern technologies creates additional employment scopes for rural women in the study area which makes a positive change in their economic and social condition. It also shows a remarkable change in women empowerment in decision making process in the study areas. However, the research points out some problems like low wage rate, lack of knowledge, social harassment, lack of training facilities etc and these should be demand for future research initiatives.

Introduction

Bangladesh is an agro-based country where about 77 % of its total population lives in the rural areas. They mostly depend on agriculture directly or indirectly for their livelihood. The future economic development of the country depends on the progress made and goals achieved in agriculture sector during the next decade. Agricultural sector contributes 20.01 % of GDP (Gross Domestic Product) (BER, 2012). So, agriculture plays a vital role in employment generation, poverty alleviation, food security, improved standard of living and increased earnings. Post harvest operations are done three times in a year after Aus, T. Aman and Boro harvest. Women spent 49.48 hr/three times year on such activities such as; weeding, threshing,

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winnowing, drying, parboiling, paddy husking by dheki, storing and other related activities (Halim and Hossain, 1993). They also remain engaged in poultry raising, cattle and goat rearing, cultivation of winter and summer vegetables, plantation of trees, within the household plant sowing, fish culture, clearing of cattle shed, etc. (Halim and Hossain, 1993).

Bangladesh is a densely populated area crowded with 14.97 million people of which 49.94 % are women (BBS, 2011). About 47.3 % of people are engaged in agriculture as laborers (Labor Force Survey-2010). It is apparent that the number of female laborers in agriculture sector is increasing day by day because of progressive mechanization in agricultural activities.

Recently, there have been few comprehensive studies on the impacts of farm mechanization on overall livelihoods of the rural population in Bangladesh. The rural laborers experienced a considerable increase in their annual income (44 to 81%), household expenditure (44 to 81%), annual savings (36 to 228%) and their household asset position (Miah et al. 2002) The increased use of PTs and mechanization, to some extent, seriously accelerate the income of small farmers and landless laborers, while contributing little to the overall productivity of farming systems (Gill, 1984; Jabbar *et al.*, 1983). Duff (1986) also pointed out the reduction of wage employment opportunities in farming due to farm mechanization. This labor is diverted to other forms of employment in non-farm activities or leisure activities (Campbell 1990). Another study conducted by Haque and Sarker (2000) showed that use of family labor decreased by 14-26% and hired laborer increased by 23-41% in different farm activities only because of PT adoption in farming. The study focused on the socio-economic characteristics of the respondents and how farm machineries are changing livelihood pattern in Agricultural women laborer.

Objectives of the Study

The study was under taken with the following objectives:

i) to know socio economic characteristics of the respondents;

ii) to identify the modern technologies used by the respondents; and

iii) to observed the changes of livelihood patterns of the respondents.

Materials and Methods

Methodology is of paramount importance in any scientific inquiry as the validity and reliability of the facts primarily depend upon the system of investigation. For this study, survey method was followed to collect data from the respondents. In this method, the researchers mostly rely on the memory of the respondents. Data have been collected from three selected villages namely Shitalgari, Rampura and Astosopur under Mithapukur upazila of Rangpur district which is 19 km away from Rangpur district headquarter. The universe of the present study was women laborers of three villages of Mithapukur upazila under Rangpur district. It includes only those women laborer who used modern technologies. A sample of 60 respondents, 20 from

each village was conducted. The study is based on a set of field level primary data which were collected from the selected respondents by face to face interview with the help of interview schedule designed for this study. The data were collected during the period from March to April, 2008. To assess the impact of modern technologies on the changing livelihood pattern of the respondents the we collected primary data in two ways that is - before adoption (1997) and after adoption (2007) of modern technologies on the following dependent variables such as change in income, change in basic needs, change in housing unit, change in supplying drinking water, change in sanitation condition, development indicators of the sample women laborers and reproductive and general health status. The secondary data were collected from Bangladesh Bureau of Statistics (BBS), Population Census reports, the daily newspapers, published and unpublished articles, etc.

After collecting the requisite data, they were processed and analyzed with a view to achieving the objectives of the study. To determine the change in some socio-economic aspects of agricultural women labor, statistical tools like percentages, ratios etc. have been applied. Age of the respondents range from 18 to 60 years on that basis, the women labors were classified into three categories: group A (up to 30), group B (30 to 40) and group C (above 40). The family size of the respondents ranged from 3 to 9 members. On the basis of their family size, the respondents were classified into three categories "small family" (up to 4 members) "medium family" (5 to 6 members) and "large family" (above 6 members).

Results and Discussions

The Study tried to find out the information about the socio economic characteristics of the respondents, use of modern technologies and assess the changes of the livelihood patterns of the respondents by using modern technologies which have been presented in the tables.

Socioeconomic Characteristics of the Respondents

Age Distribution, Family Size and Composition of the Respondents

In the study area most of the respondents (50%) are in the age group A. It also reveals that 84 % of the respondents comprise of the young (group A) and middle age (group B) categories. It is observed that percentages of male members were higher in all groups except group B. The family size and composition of the respondents on the basis of age was presented in table-1. The table indicates that about 55% of family members of group A, B and C constituted by medium family size. This may be due to the proper adoption of family planning measures among the respondents or to prevalence of single family system in the study area.

Table-1: Age Distribution, Family Size and Composition of the Respondents

Age of categories	Agricultural women labor	Family composition		Family size			
		Male	Female	Small family	Medium family	Large family	Total
A (up to 30 years)	30 (50)	98 (54.44)	82 (45.56)	7 (23.33)	18 (60)	5 (16.67)	30 (100)
B (30 to 40 years)	20 (33.33)	55 (48.67)	58 (51.32)	6 (30)	10 (50)	4 (20)	20 (100)
C (above 40 years)	10 (16.67)	28 (51.85)	26 (48.15)	4 (40)	5 (50)	2 (20)	10 (100)
All	60 (100)	181 (52.61)	166 (47.84)	17 (28.33)	33 (55)	11 (18.33)	60 (100)

Occupational Status of the Respondents

In the study area, on the basis of their wage earning, their occupations are classified in two categories i.e. main occupation and subsidiary occupation. The table-2 shows that the highest 58.33% women are involved in labor selling as their main occupation; at the same time 43.10% of them take these income generating activities as secondary occupation. About 11.67% respondents are involved in business and 13.33 % respondents had the main occupation of agriculture. On the other hand, most of the respondents are involved in more than one subsidiary occupation.

Table-2: Occupational Status of the Agricultural Women Labor/ Respondents

Types of occupation	A		B		C		All groups	
	Main	Sub	Main	Sub	Main	Sub	Main	Sub
Women labour	18 (60)	12 (42.86)	11 (55)	9 (45)	6 (60)	4 (40)	35 (58.33)	25 (43.10)
Agriculture	4 (13.3)	5 (17.86)	3 (15)	2 (10)	1 (10)	2 (20)	8 (13.33)	9 (15.52)
Fish culture	1 (3.33)	3 (10.71)	-	3 (15)	1 (10)	-	2 (3.33)	6 (10.34)
Cow rearing	2 (6.67)	4 (14.24)	2 (10)	2 (10)	-	1 (10)	4 (6.67)	7 (12.07)
Petty fussiness	3 (10)	2 (7.14)	2 (10)	3 (15)	2 (20)	1 (10)	7 (11.67)	6 (10.34)
Grocery shop	1 (3.33)	2 (7.14)	1 (5)	1 (5)	-	1 (10)	2 (3.33)	4 (6.90)
Others.	1 (3.33)	-	1 (5)	-	-	1 (10)	2 (3.33)	1 (1.72)
Total	30 (100)	28 (100)	20 (100)	20 (100)	10 (100)	10 (100)	60 (100)	58 (100)

Figures in the parentheses indicate percentages.

Land Ownership Patterns and Farm Size of the Respondents

Land is one of the most important assets in the rural areas. Ownership of land of respondent households consists of owned land, mortgaged in and leased in or rented which has been shown in table-3.

Table-3: Average Land Utilization Patterns of the Respondents

Types of land	Average Size of Land (Acres)					
	A		B		C	
	Area	%	Area	%	Area	%
Cultivated owned land	0.09	32.14	0.12	34.29	0.17	38.64
Homestead	0.07	25.00	0.08	22.86	0.10	22.73
Rented in	0.11	39.29	0.13	37.14	0.12	27.27
Rented out	0.06	21.43	-	-	0.11	25.00
Mortgaged in	0.08	28.57	0.10	28.57	0.15	34.09
Mortgaged out	0.05	17.86	0.09	25.71	-	-
Farm size	0.28	100.00	0.35	100.00	0.44	100.00

Source: Field survey, 2008.

Commonly Used of Modern Technology by Women Labor

Mechanization may increase the involvement of rural labors both at production stage and post harvest activities. Among the respondents 18.72 % use paddle thresher, 17.87% corn Sheller, 6.81 % power tiller, 13.62 % sprayers, 11.06 % shallow tube wells, 17.02 % manual weeders and 14.89 % drum seeder (Table-4).

Table-4: Commonly Used Modern Technologies by Women Labor

Age group	A		B		C		All	
Items	Used	Non-used	Used	Non-used	Used	Non-used	Used	Non-used
Paddle thresher	23 (19.83)	7 (7.44)	15 (18.52)	5 (8.47)	6 (15.79)	4 (12.5)	44 (18.72)	116 (8.65)
Corn sheller	21 (18.10)	9 (9.57)	13 (16.05)	7 (11.86)	8 (21.05)	2 (6.25)	42 (17.87)	18 (9.73)
Power tiller	8 (6.90)	22 (23.40)	6 (7.41)	14 (23.73)	2 (5.26)	8 (25.00)	16 (6.81)	44 (23.78)
Sprayers	16 (13.79)	14 (14.89)	11 (13.58)	9 (15.25)	5 (13.16)	5 (15.63)	32 (13.62)	28 (15.14)
Shallow tubewells	12 (10.34)	18 (19.15)	10 (12.35)	10 (16.95)	4 (10.53)	6 (18.75)	26 (11.06)	34 (18.38)
Manual weeder	19 (16.37)	11 (11.70)	14 (17.28)	6 (10.17)	7 (18.42)	3 (9.38)	40 (17.02)	20 (10.81)
Drum seeder	17 (14.66)	13 (13.83)	12 (14.81)	8 (13.56)	6 (15.79)	4 (12.5)	35 (14.89)	25 (13.51)
Total	116 (100)	94 (100)	81 (100)	59 (100)	38 (100)	32 (100)	235 (100)	185 (100)

Figures in the parentheses indicate percentage.

Adoption of Modern Technology and its Relationship with Social Changes

Modern farm technology is related with modern and scientific culture and management of farm enterprises. Modern technologies are pumps for irrigation, power tiller for tillage, weeder for weeding, sprayer for spreading and thresher for threshing and so on. Before threshing women prepare the courtyard with a fresh layer of mud and cow dung so that sand and dirt do not get into the rice. Women have to decide whether paddy should be soaked before parboiling and if so how long it should be. Generally women spread the grains in the courtyard or on the black tarmac surface of a road and alter them periodically with their feet or a wooden turner. The increasing use of mechanical rice mills has lightened the work burden of family farmwomen. Winnowing using a flat basket or Kula with the wind or without wind separates husk, bran and broken rice. In the research area before mechanization women laborer worked 204 days in a year, due to adoption of modern technologies it increases 280 days in a year.

Change in Income

The findings indicate that the average yearly income of the respondents increased after they had adopted modern technologies. For all groups the average income after adoption of modern technology was higher than that of "before adopting" and the average annual income was Tk. 11465 (Table-5). It was a pooled effect of mechanization in all steps of farm activities.

Table-5: Average Annual Income from Modern Technology in Agricultural Women Labor

Age group	A		B		C	
Sources of income	Before (1997) Tk	After (2007) Tk	Before (1997) Tk	After (2007) Tk	Before (1997) Tk	After (2007) Tk
Paddle thresher	5400	6125	4866	5584	4677	5394
Cronsheller	1725	1850	1644	1725	1605	1687
Power tiller	874	1020	793	992	710	910
Tractors	525	688	508	695	425	615
Sprayers	408	590	380	555	296	468
Manual weeders	702	965	636	847	612	825
Drum seeder	614	736	518	688	468	576
Shallow tube-wells	210	318	200	297	197	245
Total	10,958	12,292	9545	11,383	8990	10,720

Change in Basic Needs of the Respondent Households

Respondent families attitude towards the five basic needs were changed positively. Food consumption per year per family increased from Tk. 17512 to Tk. 22,480 after the adoption of modern technologies (increased 28.37%). Simultaneously educational expenses were also

increased from Tk. 680 to Tk. 927 (increased 36.32 %). Other parameters increased in positive trend (Table-6). It is noted that adoption of modern technologies has made crucial impact on basic needs. Respondent were benefited both ways it reduces production cost and on the hand laborer earn more money utilizing same labor.

Table-6: Average Annual Change in Per Family Basic Needs Consumption of the Respondent Households

Items	Before (Tk.) (1997)	After (Tk.) (2007)	Net change (Tk.)	Change in (%)
Food consumption	17512	22,480	4968	28.37
Educational	680	927	247	36.32
Clothing	1384	1546	162	11.71
Medicare	750	979	229	30.53
Housing	1015	1233	218	21.48

Credit Distribution According to Source of Credit

The ultimate target of rural development in Bangladesh focuses on to uplift the living standard of the rural masses through encouragement of socioeconomic activities in rural areas. In this account the overall impact of micro credit towards under study is quite commendable. The sources of micro credit in the areas under study area were Grameen Bank, BRAC, Proshika and ASA. The first two were main source from where women labor received micro credit. Loan received by women labour form Grameen Bank and BRAC were 44.57 % and 32.55 % respectively. The rest two had no or limited function in the study area (Table-7).

Table-7: Credit Distribution According to Sources of Credit (Average in Taka)

Age group	Name of the organization				
	GB	BRAC	Proshika	ASA	Total
A	6500 (48.32)	3200 (23.79)	1250 (9.29)	2500 (18.59)	13450 (100)
B	4850 (41.14)	4060 (34.44)	840 (7.12)	2040 (17.30)	11790 (100)
C	4585 (43.63)	4375 (41.63)	-	1550 (14.75)	10510 (100)
All	5311 (44.57)	3878 (32.55)	696 (5.84)	2030 (17.04)	11915 (100)

Figures in the parentheses indicate Percentages

Impact of Average Annual Income on Women Labor Households

The impact on average annual income of the women labor households were taken in consideration. After Adopting modern technologies, the principal components of household income of women labor were labor selling, agriculture, non-agriculture activities. Three

categories of household annual average income increased after adopting modern technologies and value increased by 21.13 % 20.96 % and 19.88 % respectively. So, the findings indicate that there is a positive change in income because of adopting modern technologies.

Table-8: Impact on Average Annual Income of the Agricultural Women Labor Households

Age group	Sources	Before (Tk)	After (Tk.)	Net change	Change (%)
A	Women labour under technology	10,800	14400	3600	33.33
	Agriculture	14565	16155	1590	10.91
	Non-agriculture	12476	15283	2807	22.50
	Total	37841	45838	7997	21.13
B	Women labour under technology	10448	13410	2962	28.35
	Agriculture	14793	16928	2135	14.43
	Non-agriculture	11044	13311	2267	20.52
	Total	36285	43649	7564	20.96
C	Women labour under technology	10022	12720	2698	26.92
	Agriculture	15818	18234	2416	15.27
	Non-agriculture	9504	11415	1911	20.11
	Total	35344	42369	7025	19.88

Impact on Average Annual Expenditure of the Respondents

Family expenditure is an important indicator to identify their living condition. Women's contribution to their family expenditure is also an important indicator of economic empowerment. In the study areas, women labor spent their income on different purposes such as agriculture, non-agriculture and family expenditure. Table-9 shows that the percentage change three categories of household average expenditure 21.15 %, 18.67 % and 18.51 % respectively after adopting modern technologies. This expenditure pattern indicates changing attitude towards life and improvement of the standard of living due to women's contribution to family expenditure.

Table-9: Average Annual Expenditure Pattern of Women Labour Households

Age group	Sources	Before (Tk.)	After (Tk.)	Net change (Tk.)	Change (%)
A	Agriculture	7564	8064	500	6.61
	Non-agriculture	7244	7588	344	4.75
	Family expenditure	22326	29336	7010	31.40
	Total	37134	44988	7854	21.15
B	Agriculture	8056	8179	123	1.53
	Non-agriculture	7812	8009	197	2.52
	Family expenditure	20207	26625	6418	31.76
	Total	36075	42813	6738	18.67
C	Agriculture	8627	9513	886	10.27
	Non-agriculture	5593	7057	1464	26.18
	Family expenditure	20852	24997	4145	19.88
	Total	35072	41567	6495	18.51

Change in Housing Unit

One of the major indicators is housing pattern. In the study area (Table-10) housing type before involvement with different small enterprises, on an average 48.34%, 38.33%, 10.00% and 3.33% had straw, tall, tin and half building respectively before adoption with different enterprises, whereas, data after adopting showed quite opposite i.e. 35%, 30 %, 28.33% and 6.67% were straw, tall, tin and half building respectively.

Table-10: Change in Housing Unit of the Agricultural Women Labor Household

Age group	Before (1997)					After (2007)				
	Straw	Tall house	Tin house	Half buildin	Total	Straw	Tall house	Tin house	Half buildin	Total
A	15 (50.0	14 (46.6	1 (3.33)	0 (00.00)	30 (100	11 (36.6	12 (40.00	7 (23.3	0 (0.00)	30 (100
B	10 (50.0	7 (35.0	2 (10.0	1 (5.00)	20 (100	7 (35.0	5 (25.00	6 (30.0	2 (10.00)	20 (100
C	4 (40.0	2 (20.0	3 (30.0	1 (10.00)	10 (100	3 (30.0	1 (10.00	4 (40.0	2 (20.00)	10 (100
All group	29 (48.3	23 (38.3	6 (10.0	2 (3.33)	60 (100	21 (35.0	18 (30.00	17 (28.3	4 (6.67)	60 (100

Change in Supplying Drinking Water

It refers to the condition of drinking water source of the women labor household both before and after adoption of technologies. There were two types of sources of drinking water namely,

neighbor's and own tube-well identified in this study. Table-11 reveals that there has been change in the source of drinking water after involvement with technologies, while 53.33% household used water from neighbors tube-well, before: now there was used 23.33%. Achievement of own tube-well used has increased by 76.67% in all groups after adoption with technologies.

Table-11: Changes in Supplying Drinking Water of Respondents Households

Age group	Before (1997)		After (2007)		Total
	Neighbors tube-well	Own tube-well	Neighbors tube-well	Own tube-well	
A	17 (56.67)	13 (43.33)	9 (30.00)	21 (70.00)	30 (100)
B	11 (55.00)	9 (45.00)	4 (20.00)	16 (80.0)	30 (100)
C	4 (40.00)	6 (60.00)	1 (10.00)	9 (90.00)	10 (100)
All group	32 (53.33)	28 (46.37)	14 (23.33)	46 (76.67)	60 (100)

Figures in the parentheses indicate percentage.

Change in Sanitation Condition

It refers to the condition of sanitation of the respondent both before and after adoption of modern technologies. There were three types of toilet facilities found in the study area i.e. Katcha, Semi-pacca and sanitary latrine. Table-12 shows the toilet condition before and after adoption of modern technologies. There has been a notable change in sanitation condition after adoption, while, 66.67% used katcha latrine before there was 38.33% used katcha latrine after adoption and 51.67% household used semi pucca latrines, from only 31.67% before adoption, 10.00 % household used sanitary latrines after adoption technologies.

Table-12: Changes in Sanitation Condition of Respondents Households

Age group	Before			After			Total
	Katcha	Semi pucca	Sanitary	Katcha	Semi pucca	Sanitary	
A	21 (70.00)	9 (30.00)	-	13 (43.3)	16 (53.3)	1 (3.33)	30 (100)
B	14 (70.00)	6 (30.00)	-	8 (40.00)	10 (50.00)	2 (10.00)	20 (100)
C	5 (50.00)	4 (40.00)	1 (10.0)	2 (20.00)	5 (50.00)	3 (30.00)	10 (100)
All group	40 (66.67)	19 (32.67)	1 (1.67)	23 (38.3)	31 (51.67)	6 (10.00)	60 (100)

Figures in Parentheses indicate percentage

Development Indicators of the Respondents Households

There eight concepts were considered as important components of development indicators of a respondents' family. Therefore, they were asked to indicate if their conditions in each of these components were high, medium and low as a result of their improvement with enterprise activities. Table-13 reveals that most of the respondents of all three categories reported "medium" development in different indicators. About 43% reported medium development in increased knowledge and skill, 47% in improved food and nutritional conditions, 28% change in food habit, 38% in improved family health and sanitation and 42% in increased social prestige. But 48% in medium category for recreational facilities reveals the fact that their morality and mind and 37% in increased savings.

Table-13: Development Indicators of the Respondent Households

Age group Indicators	A			B			C			All group			Total
	H	M	L	H	M	L	H	M	L	H	M	L	
Increased knowledge and skills	11 (36)	12 (40)	7 (23)	7 (35)	9 (45)	4 (20)	2 (20)	5 (50)	3 (30)	20 (33)	26 (43)	14 (23)	60 (100)
Improved food and nutrition condition	12 (40)	14 (47)	4 (13)	6 (30)	11 (55)	3 (15)	4 (40)	3 (30)	3 (30)	22 (37)	28 (97)	10 (17)	60 (100)
Change in food habit	17 (57)	8 (27)	5 (17)	10 (50)	6 (30)	4 (20)	2 (20)	3 (30)	5 (50)	29 (48)	17 (28)	14 (23.3)	60 (100)
Improved family health and sanitation	9 (30)	8 (27)	13 (43)	6 (30)	9 (45)	5 (25)	2 (20)	6 (60)	2 (20)	17 (28)	23 (38)	20 (33)	60 (100)
Increased social prestige	5 (17)	14 (47)	11 (37)	3 (15)	8 (40)	9 (45)	2 (20)	3 (30)	5 (50)	10 (17)	25 (47)	25 (42)	60 (100)
Increased recreational facilities	12 (40)	15 (50)	3 (10)	7 (35)	10 (50)	3 (15)	2 (20)	4 (40)	4 (40)	21 (40)	29 (48)	10 (17)	60 (100)
Increased savings	7 (23)	12 (40)	11 (37)	2 (10)	7 (35)	11 (55)	3 (30)	3 (30)	4 (40)	12 (20)	22 (37)	26 (43)	60 (100)
Involvement with other organizations	8 (27)	10 (33)	12 (40)	4 (20)	6 (30)	10 (50)	2 (20)	2 (20)	6 (60)	14 (23)	18 (30)	28 (47)	60 (100)

Note: H= High, M= Medium, L=Low and T= Total

Decision Making Power

It is evident from the table that the decision making indices of participants increased immensely on issues of enrolment of children's schooling. Table-14 shows the indices of the respondents on different decisions making items after adopting modern technologies. It is observed for all respondents whom are contributing to the family expenditure.

Table-14: Average Change in Decision Making Status of Agricultural Women Labor

Matters of decision making	Respondents of agricultural women laborers = 60					
	Before	Percent	After	Percent	Net	Change
Enrolment of children at school	24	40.00	47	78.33	23	95.83
Buying and selling of land	21	35.00	43	71.67	22	104.76
Involvement with NGO or cooperative society	19	31.67	38	63.33	19	100.00
Visit to relatives	17	28.33	26	43.33	9	52.94
Vaccination of children	23	38.33	54	90.00	31	134.78
Family planning decision	20	33.33	33	55.00	13	65.00
Spending own money	22	36.67	31	51.67	9	40.91
Marriage of sons and daughters	25	41.67	29	48.33	4	16.00
Borrowing or lending money	21	35.00	39	65.00	18	85.71
House repairing	25	41.67	27	45.00	2	8.00
Purchase of household necessities like clothing, ornaments etc.	30	50.00	51	85.00	21	70.00

Buying and selling of land, involvement with NGOs or cooperative society, visit to relatives, vaccination of children, family planning decision, spending own money, marriage of sons and daughters, borrowing or lending money, house repairing, purchase of household necessities like clothing, ornaments etc. Decision making towards enrolment of children at school was 78.33% and vaccination of children was 90.00%. Involvement with NGO or cooperative society was 63.33% after adopting modern technologies. These refer to the positive changes in women empowerment in the study areas.

Problems Faced in Adopting Modern Technologies

The problems faced by women labor in adopting advanced technologies have been showed through the table below (Table-15). The Table reveals that 78% of respondent are facing the problem which is "lack of capital". Women laborers are most alienated class of the society. About 72% of respondent finds the price of equipment very high. It was one of the crucial problems of the respondents. Again "lack of training facilities is another problem faced by about 92% of respondent. There is no training institution to provide training to them on the operational techniques of modern equipment. Again, 52% of respondents encounter social harassment. Rural people have some religious customs which act as a barrier for women to work outside at income generating activities. The interest rate is considered very high to 85% of the respondents.

Table-15: Problems Associated with use of Modern Technology

Types of problems	Respondents of Women laborer =60			
	High	Medium	Low	Not at all
Lack of capital	47 (78.33)	11 (18.33)	2 (3.33)	-
High price of equipment	43 (71.67)	14 (23.33)	3 (5.00)	-
Lack of training facilities	53 (88.33)	5 (8.33)	-	2 (3.34)
Social harassment	34 (56.67)	18 (30.00)	5 (8.33)	4 (5.00)
Lack of credit	32 (53.44)	18 (30.00)	5 (8.33)	5 (8.33)
High interest rate	51 (85.00)	9 (15.00)	-	-
Lack of Knowledge	48 (80.00)	10 (16.67)	1 (1.67)	1.67

Conclusions

The results of the present study verify that mechanized cultivation has some positive effects on generating employment and income of women labor. As a result, positive changes have been brought about in their economic, social and empowerment indicators. With the consequences of the changes of these indicators, economic and social status increased substantially. Therefore, the livelihood patterns improved among the respondents households. At present, avenues for work, working days as well as yearly income of the women labor have moderately increased than ever before. However, only a handful of laborers can save a little amount during the whole year. Under these circumstances, policy makers and extension worker should encourage women laborers to adopt modern technologies for mechanized cultivation. In the study area, there was a wide gap in daily wage rates between men and women laborers. Policy makers have scope to pay attention to solve this discrimination in wages. Most of the potential laborers were found to be unskilled and/or semi-skilled in the study areas. Only a few skilled laborers were found to be earned a quite substantial amount of money a year. Some vocational training programmes for enhancing productive efficiency of rural women workers, more especially in field of various agricultural and non-agricultural activities could be a positive step for changing their lots. Department of Agricultural Extension (DAE) and other concerned organizations examine the existing problems of the women labor and necessary steps may be taken to overcome these problems.

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