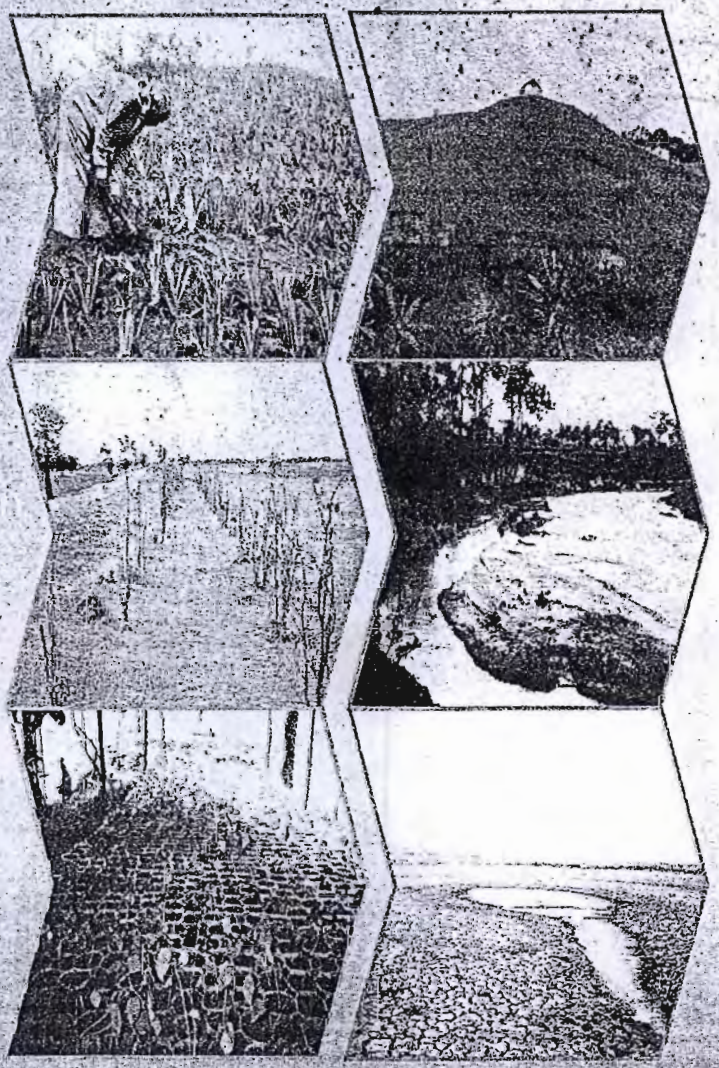
# MACH

*Management of Aquatic Ecosystems through Community Husbandry*

Draft

Report on

## Hail Haor Watershed Management Plan



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# EXECUTIVE SUMMARY

## 1. Overview of the Watershed Management Plan

The development of *Hail Haor* watershed management plan is supported under the umbrella of MACH project being funded by USAID through Winrock International. The plan, prepared by the Center for Natural Resource Studies (CNRS), envisages integrated development of *Hail Haor* basin and its watersheds spreading over the Satgaon, Foyzabad and Balishira hill ranges of the Sreemongol Upozila of Moulvi Bazaar district.

Bangladesh, though by and large a flat terrain country, its north-eastern region has a unique undulating landscape formed during the tectonic movement of the continental plateau. In the process, big water bodies with deep depressions, locally called *Haor*, had been formed naturally. The *Hail Haor* and its watersheds, the command area of this management plan, is situated in this north-eastern region, and is unique having a distinct hydrological regime that governs the ecosystem. *Balishira*, *Satgaon* and Foyzabad hills, which are the watersheds of *Hail haor*, drain water to this *Haor* through a large number of hilly streams as well as overland flow. High rainfall, deep forests, a multitude of riparian vegetation and highly productive wetlands made this part of the country a natural sanctuary for diverse and productive aquatic and terrestrial flora and fauna.

In the not too distant a past, *Hail Haor* watersheds with its diverse range of habitats had been a depository of rich biodiversity. But due to wanton destruction of the watershed vegetation and changing of land configuration through unwise soil working on fragile sloping terrain, and also destruction of wetland vegetation and aquatic resources of the *haor* basin by indiscriminate felling and overexploitation, the resource base is now in a critical stage with many species of flora and fauna either totally extinct or dangerously threatened with extinction. If the trend of destruction and misuse continues unabated, this will bring disaster for the country besides resource scarcity, growing resource deficit, and multi-dimensional sufferings of the citizens. Addressing this catastrophic situation calls for immediate remedial interventions. However, the magnitude of activities required for remedy is so big, and the intermingling of human habitation with the resource base is so intimate and intricate that remedial measures without people's active participation in the problem identification, program planning and implementation, and enforcement of conservation measures are not likely to bring sustainable results. MACH project has therefore been launched to halt further deterioration of the already aggravated situation, ameliorate the devastated resource base with exacting interventions, re-create the lost resources and improve the degraded ones as quickly as feasible following the strategy of community-based development approaches.

## 2. Goals and Objectives of the Management plan

The Goals and objectives of the plan is to demonstrate on a sub-watershed scale, improved land and water management practices that are conducive to improving the quantity and quality of water, reducing the sediment inflow into the haor basin, augmenting soil fertility and agricultural productivity, creating congenial habitat for forest-based resouree production and long term sustainable utility of *haor* basin as productive fishery ground. The recommended land and water use praetices would be environmentally sound, technically appropriate, socially acceptable and economically justifiable, and would hopefully ensure sustainable supply of the overall natural resources for enjoyment and benefit of the citizens.

## 3. Restoration Planning

*Hail haor* watershed with its vast undulating area coverage is a very complex biota having diversified land-use and over exploited resource base with degraded or depleted natural resource. Type of resource as well as economic status of user communities of the watershed, their origin, customs and religious belief differ with people living at different elevation situations of the watershed. Various criteria are required to be considered in regard to restoration of watershed as well as effecting development of adjoining villagers. These criteria, falling under the broad category of (i) Restoration criteria and (ii) Rural development criteria, have been carefully analyzed and considered in the process of carrying out restoration planning and prescribing various remedial measures.

## 4. Watershed Ecosystem Management Plan

### i. Awareness Campaign

To aware the watershed living communities on the functionality of watershed and interactions of the user communities, and also on sustainable natural resource management, strong awareness campaign is necessary and would be conducted during the plan period throughout the watershed. To this end, various tools and strategies like - *Uthan Baithak*, village level meeting, *Bazaar* meeting, *Baul* song, village d*rama* and rally would be organized. School awareness program and cross visit of the beneficiaries to successful demonstration sites would be organized. Posters, leaflets, pamphlets and the like, with environmental messages would be developed and distributed. Depending on the population density, clustering of the settlements and accessibility the number of meetings and other activities would be decided and conducted. Agreed number of such activities would then be monitored both on numbers, quantities and outputs, and in the agreed manner and time frame.

### ii. River/Flood Plain Habitat Restoration

A significant portion of the rural community living in the neighborhood of *Hail Haor* are dependent on *Charas*, Rivers, and *Beels* as well as the surrounding watershed resources for their basic livelihood and food security. For supporting the expanding population, short-sighted agriculture extension programs were undertaken in the past without considering long term damage to ecosystem. These programs have seriously degraded wetland habitat with consequent reduction of wetland product output. The connectivity among water bodies of different *beels*, canals and rivers also deteriorated due to siltation that ensued in consequence of such programs.

This plan aims at rehabilitation of the aquatic and terrestrial habitats by adopting participatory approaches as the most pragmatic way of achieving the desired sustainable results. Restoration of the watershed and wetland habitats would be achieved through aggressive soil and water conservation measures including re-covering of the denuded catchment areas with vegetation and adopting appropriate land-use management and cultural practices. De-siltation measures include program for re-excavation of 40 ha of *Beel* area and 10 km canal bed within the Haor basin in the next 3 years(2001-2003). More *beels* and *khals* need re-excavation and these are identified according to the desire of the community as well as on the basis of technical and strategic considerations.

Restoration of connectivity between *Kushiyara* and *Hail haor* is contemplated though re-excavation of *Shakha Borak* trunk canal and 5 other canals off *Shakha Borak* to *Boro haor*. A total of 30km stretch canal is planned for re-excavation in this program to re-establish connectivity. To restore and enhance convenient environment of the wetland/floodplain, typical

swamp forest species like *Hijal, Koroch, Borun. Pitali, sheora, Jarul* etc., reeds like *Murta, Nol, Khagra, Ikr, Binna* grass, and Cane will be planted on available swampland. Protection will be afforded to 5 ha swamp land in appropriate location in the *haor* basin to facilitate recruitment of natural regeneration and watching out vegetation succession.

The plan lays high emphasis on awareness creation among the resource users regarding the importance of, and necessity for swamp plantations in fostering fisheries development and attracting local and migratory birds that have symbiotic relationship with productive fisheries. Suitable community organisations will be evolved at different tiers of the society and administration to develop, manage and regulate the harvest of natural resources of *Haor* and watershed. Community's willing and active participation will help restoration/ enhancement of woody and non-woody vegetation, and also help establishing sustainable management of the resource base and the resources.

Riparian vegetation along 25-30 numbers of *chharas* will be restored for stabilizing *chhara* banks, and also create a tree covered corridor for wildlife movement. Afforestation will be done in the upper reaches of the watershed to reduce erosion and increase ground water percolation recharging the aquifer layer which will eventually augment dry season stream flow and help retention of grater depth of water in the *haor* basin.

Land use management in the hills and valleys will take the shape of appropriate orchard management through extension programs. This will ensure optimal and rational use of water, take care of proper land use and reduce siltation of water bodies. Sanctuaries for wildlife and aquatic living beings will be established to enhance the population of indigenous wildlife and recruitment of fish. MACH project contemplates to establish 30-35 aquatic sanctuaries within the *Hail Haor* basin.

iii. **Land Use Management**

a. Tea: About 36% land area of the watershed is estimated to be under intensive tea cultivation which follows contour line planting. Despite tea planters claim that splashing action of rain drops and soil erosion from run-off are not severe under tea because of overhead vegetation coverage that intercepts rain drops and reduce its splashing erosive power, soil erosion and land slide do occur especially in delicate land situations. To counteract this, at times various soil holding grasses like Guatemala, Java Citronella, Vetiver are planted by tea growers. The present efforts in this direction are small scale and casual activity. Tea gardeners would be persuaded to undertake such grass cultivation and other soil conservation and land reclamation contrivances as regular activities particularly on sloping watersheds.

b. **Lemon and Pineapple**: Some 4% of the *Hail Haor* watershed is covered with lemon and pineapple gardens; cultivation is pursued on sloping terrain. These lands are overwhelmingly sandy soils and highly erosive. Currently, the cultivators follow 'across the contour' plantation technique which is highly provocative of soil erosion. Adoption of 'contour plantation' technique with nurse crop in substitution of the damaging 'across the contour' system as at preset, and avoidance of steep slopes (> 45% gradient) for pineapple cultivation are the key strategy to reduce soil erosion. Pineapple gardeners are shy of adventuring new cultivation method. Popularizing contour planting' technique will be done under the project by establishing demonstration plots. Two such demonstration plots have already been established during 2001 in the upper reaches of *Joita chhara* and they are performing well. This plan prescribes for establishing 8-10 more such demo plots in conspicuous locations during 2002 -2003 so that the local gardeners witness the success and beneficial effects of contour plantation culture, and are convinced and encouraged to adopt the technique.

The plan also recommends adoption of intensive cropping management for lemon and pineapple on undulating land at the upper catchment of the watershed. Conversion of natural landscape by bench cutting/ terracing is mostly done by the lemon and pineapple planters that causes terrible soil erosion and landslide. This has got to be stopped on dangerous steep slopes, and regulated in flatter terrain through appropriate interventions like terrace retaining hedgerow planting with soil binding grasses and plants( *Boga medula*) in the down slope.

Less water requiring crops like wheat, maize etc. would be experimented in the water scarce areas of the watershed. This will be conducive to increased water flow into the *haor* basin. For the entire watershed areas of *Hail haor*, about 50-60 dry farming demonstration plots would be set up for dissemination of dry farming idea. Agricultural extension services and its awarcness programs on the relevant topics would be conducted in support of the dry farming.

### iv. Water Use Management

Water needs, accessibility to water sources, water use and water sharing are of crucial importance in determining the soundness of watershed management functions. An estimated 6 billion $m^3$ of water flow into the *Haor* per year through the hilly *Chharas*. In the recent decades, the dry season water flow in the streams and thence to the *Haor* basin is decreasing due to lesser percolation and poor recharging of underground aquifers. While forest denudation is responsible for the former, withdrawal of water at the upper reaches for irrigating crop lands and orchards in the dry season is partially causing less water flow into the *haor* basin. Interventions like afforestation, regeneration of riparian vegetation, reduction of water losses through run-off etc. are the appropriate basic strategies to promote greater percolation into the sub-soil during rains and thereby increase seepage and dry season flow. These interventions will be adopted.
Pragmatic water sharing is very important for dry season farming in the different reaches of the stream sections. Water loss by evaporation during dry season irrigation is tremendous. Awareness program and right agricultural technology regarding effective irrigation would be disseminated to the farmers with the objectives of achieving reduction of water losses. Sluice gate would be established in some streams to demonstrate proper distribution of water in the upper and lower reaches as well as to reduce misuse. Water reservoirs or ponds would be established and revived for facilitating irrigation.

Introduction of less water requiring crops in the water scarce area should be considered an effective strategy to reduce water needs; this will be encouraged. Orchard management extension program would also be helpful for rational distribution of surface water. To this effect, appropriate extension service will be made available

### v. Fisheries Management

Because of a number of exacting reasons, the rich fisheries of *Hail haor* is progressively degraded and this trend is continuing. Of the various causes of this adversity, habitat degradation is the formidable one. The heavy silt load coming from the catchment is responsible for siltation of the water bodies and creation of unfavorable habitats for fish. Loss of connectivity between water bodies is yet another crucial factor degrading the habitat. Lack of indispensable conservation enforcements at different times of the year and at different stages of fishes' life cycle, absence of right management practices and fish overexploitation are other important causes for declining fisheries.

Community-based resource conservation, development and management through direct involvement of local resource users are the conceptual basis for the fisheries development under

the plan. The project intends to find a system and strategy of management along with the stakeholders through participatory planning, management and conservation enforcements that will include periodic ban on fishing, ban on fry harvesting, stop de-watering of water bodies and other activities as decided by RMOs. Awareness campaign will be conducted through out the watershed explaining the fisheries production system, sustainable harvesting, importance of brood stock and need for their conservation, water body's connectivity, danger of over-exploitation etc. Preparation of a Management Manual in a simple and local varnaculuar language highlighting the basic fisheries management aspect is also contemplated. An agreed guideline would be developed and supplied to the community resource managers for affording systematic management of the fisheries resource.

Natural recruitment through successful migration of fish from wintering habitats to breeding and feeding habitats is a key factor for sustenance of floodplain fisheries. Ecological management of floodplain fisheries is a major focus of this management plan. The project activities will address the management of the ecosystem and emphasize habitat restoration and enhancement, conservation of species, and prudent use of resources. The plan prescribed the following fish restoration/ enhancement interventions

- **Fish Habitat Restoration and Enhancements:** This would be accomplished through restoration and enhancement of the quality of habitat that was degraded due to anthropogenic and natural causes so that the natural and self-regenerating system of capture fisheries is ensured. Activities include de-siltation of canals and *beels*, wetland afforestation with hydrophilic species, fish-friendly operation of sluice gates, and re-establishment of connectivity between Kushiara river and Hail haor.

- **Fish Sanctuary/Wintering Refuge:** Dry season is the crucial time experienced by the fish population when most of the fish habitats are dry or nearly dry. At this time, fishing pressure goes up, water quality degrades and water abstraction peaks. The cumulative effect of all these factors make the fish vulnerable to higher natural and fishing mortality. To address these adverse issues, the plan provides for re-excavation of *beels*, *pagars* and canals within the project area to create sufficient extent of dry season fish-refuge. Small fish sanctuaries in river pools and *beels* would be developed with brush shelters to enhance habitat quality and help preserve parent stock of fish, shrimp and other aquatic biota. The project would motivate the community to recognize and respect the refuge area so that parent stock is conserved during the dry season. The overall effect would be the re-population of the habitat for the next monsoon.

- **Wise Use/Sustainable Fishing:** Sustainable fishing is extremely important to ensure continued supply and productivity without which natural fisheries collapse. Sustainable fishing of course does not mean complete discontinuation of fishing. Rather, it comprises flexible fishing regulations which the communities themselves can regulate and practice. The regulations could be time specific, gear specific and even location specific. The project would therefore encourage the users/fishers to adopt wise resource use practices in their water bodies and simultaneously also cater for tiding over fishers' sustenance during hardship period when they are not fishing. This could be effected by stopping, for example, fine mesh seine net fishing for 4-6 weeks at the beginning of monsoon flooding. This would allow many species to breed and many young fish to put on quick, early growth. Similarly, use of the *current net* would be restricted for specific time period in the defined areas, as deemed appropriate.

- **IGA to Help Achieving sustainability:** Attainment of sustainability is only possible when the local users, who depend on the resource for their livelihood, are educated, motivated and given

the responsibility of managing their own resources. The fisher community will therefore be educated and motivated by the project staff about the need for sustainable fishing. They are of course aware of this fact but driven by extreme poverty and lack of alternative income source for subsistence, they painfully violate the basic norms of fishing. So IGA will be introduced to tide over the crisis period when fishing would need to be compulsorily stopped in the greater interest of sustainability.

vi. **Habitat Restoration**

a. **Re-generation of Vegetation:** Based on the currently practiced land culture and vegetation coverage and its management protocol, 9 different types of habitats are recognised in the Hail *haor* watershed. These habitats are: b*eel,* paddy fields, human settlements, riparian zone, lemon and pineapple garden, tea garden, rubber garden, natural forest and plantation forest. With no exception, all these habitats are continually degraded due to both natural and man made causes. Re-establishing the ecological balance and mending the damages already done are the practical ways and means to habitat restoration.

For wildlife habitat restoration, natural and plantation forest cover would be conserved and augmented.. Through awareness campaign among the forest resource harvesters and forest neighbors, as well as through stringent enforcement of law, the problems of soil conservation and watershed management are sought to be addressed. Deforestation, hunting and shooting, over harvesting of resources. would be discouraged or even banned with appropriate provisions of compensatory measures for the owners and users. To effect all these regulatory measures, the project will maintain cordial, close liaison with FD.

(1). **Restoration/Rehabilitation of Riparian Corridor:** Degradation of riparian corridor resulted in isolation/degradation/destruction of the natural habitat. The ecological balance has obviously been disturbed. Because of the degradation and most often isolation of the habitats, the wildlife movement became restricted, and they become endangered due to shortage of food in limited area and lack of secured shelter. Riparian vegetation to function as a corridor for wildlife movement, stream bank stabilization and building additional resource for the RMO members will be established under the MACH project. When established, sueh plantation would restore important connectivity among different habitats.

(2). **Contour Hedgerow Establishment:** To reduce the quantum and speed of surface run-off from the sloping terran, and to accelerate the water infiltration into the sub-strata for better recharging of the aquifer layer of the watershed, live hedges of *Boga madula*, Java Citronella and Vetiver grasses and other ground flora would be established on the hill slopes in contour line layout especially in the orchards. When established, these will have the effect of reducing sheet and gully erosion. This will be a collaborative program with the gardeners and prior training to their field workers and supervisory staff would be necessary. MACH project will endeavor to impart such technical training. A number of nurseries would be established to produce and supply requisite *vetiver* slips/tillers.

(3). **Afforestation and Reforestation**

According to tea estate management and lemon-pineapple gardeners, about 2000 ha of lands are lying barren in various gardens in the upper catchment of watersheds. These barren hills and hillocks are currently contributing to severe soil erosion and land slide. These delicate lands would be brought under afforestation program under the MACH project in collaboration with the

landowners where multi-storied vegetation with ground cover will be established. The reforestation program in the watershed upper catchment would require about 5 million tree saplings. Indigenous tree species like *Chapalish, Chickrassi, Garjan, Telsur, Champa, Rongi, Jarul, Sil Koroi*, and domesticatcd fast growing and high valued exotics like *Mahogony, Akashmoni, Mangium*, and *Teak* should be the species choice. Afforestation in the encroached *Khas* and Tea estate lands would be collaborative in respect of investment and profit sharing.

**(4) Swamp Plantation**

Inside the *Hail Haor* basin, there exists some raised land, locally called *Kanda*. These are currently dominated by natural growths of *Dholkalmi* and *Hogla* (in the dry season only). In order to improve *Haor* ecology and to enhance quality of habitat for fish and birds, as well as for creating new resources for the neighboring people, swamp forest will be recreated on the *kanda* lands and also along the banks of the *chharas*. Hydrophilic trees viz. Hijal, *karach, kadam, jarul, Pitali. Borun. Sheora, and reeds like Nol, khagra, hogla, chailla, binna* grass etc. and cane would be re-introduced to improve aquatic habitat. To enhance the quality of aquatic habitat, about 100 ha of fallow raised land would be planted under the swamp land afforestation program.

**(5). Establishment of Project Nursery**

To be able to plant seedlings of the desired species and of the prescribed height specifications (2 m tall), the project will be required to raise its own nursery stock because hydrophilic species seedlings are not raised in commercial nurseries. Nursery of swampland species should constitute an important activity under the MACH project.

**b. Bio-reserves and Sanctuary Development**

The bio-diversity of *Hail haor* watershed has declined alarmingly. The degrading trend is continuing even now. The current threats to diversity loss arise primarily from habitat destruction, over exploitation, population expansion and global change. Despite extinction or endangered status of many indigenous species, some 164 wildlife species have been recorded in recent inventory that includes 5 amphibian, 17 reptilian, 88 avifaunal and 19 mammalian species in the *Hail haor* watershed. The plan recognized the need to ensure conservation of the existing bio-diversity through effective habitat protection and facilitating undisturbed regeneration. Part of the forest area should be declared as bio-reserves for wildlife. For ensuring a safe home for the remaining wildlife population of the project area, a buffer zone should be established around the *Satgaon* and *Lawachhara* Reserve Forests where only scientific activities would be allowed; no commercial exploitation of resource nor plantation activities should be permitted. To materialize this objectives, the project will establish higher level contact with FD and MOEF.

In the swampland, afforestation would be done to create sanctuary and habitat for aquatic wildlife and migratory birds, and restore symbiotic relationship between fish and vegetation, and fish and bird population. A 5 ha sanctuary of aquatic wildlife is proposed to be established within the proposed 100 ha swamp forest to study the nature and natural changes in their true perspectives.

**vii. Rural Development Management**

Population pressure on one hand, and lack of technological development for proportionate increase in agricultural and horticultural productivity per unit area to match up with increased

demand on the other, are the primary causes for overexploitation of resource, misuse of resource base and the overall degradation of natural resources and plant and animal habitat. A combination of rectification portfolios including conservation practices, wise use of land, and reduction of degrading pressure on land are necessary to restore the hail *haor* watershed.

IGA to off-set total dependence on resource harvesting from *haor* and watershed, and avoidance of risk entailing hill cultivation are required to reduce human pressure on the watershed resource base and halt its degradation. RRA conducted by MACH project revealed that the project area population mostly chosen cattle farming, poultry rearing, orchard raising and tree plantation as IGA. However, technical and financial support would be needed by them to create efficient manpower, help adopting right technology and permit necessary investment for IGA. The project would endeavor to provide for all these essential services.

### viii. User Management Group Development

Management and protection of natural resources at the initiative and involvement of the user community is the pragmatic way to make such resources sustainable in the long run. But prevalence of poor literacy in the rural areas is a fundamental snag standing on the way of such organized participatory development. It is necessary to aware and educate the user community about the current status of the natural resources around them and the impending need for their proper development and management exercising due restraint in resource harvesting. The project concentrates on, and intends to work for sustainable development and pragmatic management of the overall watershed resources following a community-based management approaches.

The plan therefore proposes that development activities conceived for *Hail Haor* watershed improvement like rehabilitation of water bodies, connectivity improvement, regeneration of riparian vegetation, erosion protection etc. would be implemented with the active participation of the community user groups. Befitting **Resource Management Organizations (RMO)** would be formed involving all the resource users surrounding the resource base to conserve and sustainably manage the resources along with constant participatory monitoring and evaluation. Standard procedure for stakeholder analysis and their incorporation in the RMOs would be ensured.

A second tier committee, **Union Resource Management Committee (URMC)**, would be formed for each Union. This will include representation from all the RMOs of the Union and headed by UP chairmen. While the RMOs would take care of individual resource base and resources therein, performance of all these RMOs would be taken care off by the URMC.

A final APEX body for the *Hail Haor* watershed and water bodies would be formed at the Upazila level. This APEX body would include local government representatives (UP chairmen), *Upazila* level GoB officials of concerned departments, NGOs concerned in this program. This body, called the **Local Government Committee (LGC)**, shall bring management issues to the notice of the relevant central government authority (Ministry) concerned with natural resource management of the watershed and *haor* basin. When fully worked, a total of 50-60 RMOs, 7 URMC and one APEX body (LGC) would required to be formed for the entire *Hail haor* watershed catchment and *haor* basin.

### ix. Monitoring

In order to keep proper track of the direction of program activities towards reaching the desired

goals and achieving the set objectives, regular monitoring would be required and would be conducted. The intermediate findings from the monitoring data would be analyzed, on-going evaluation done and appropriate management interventions would be adopted. Evaluation of the project would be based on the baseline scenario and impact monitoring. The following monitoring tools would be used:

i) ***Photo Points*** Photo points at 1 km distance apart are permanently fixed on the *chhara* bank by fixing T-shaped RCC pillars. Photographs showing existing bank condition of *chhara* at these fixed points would be taken which will serve as a baseline status of *chhara* bank before intervention. Such photographs, facing both upstream and downstream directions of the concerned *chhara,* would be taken. Successive pictures would show the status of bank along with riparian vegetation before the project and with the project intervention, at different stages of the project life.

ii) ***Water Discharge:*** Hydrology of *Hail Haor* watershed is directly influenced by the drainage of hilly streams and surface run-off from the watershed. Out of 59 big and small chharas draining to the *Haor,* about 20 representative *chharas* will be selected for water discharge monitoring. The year round water discharge monitoring would be conducted at 7 days interval.

iii) ***Sediment Load:*** Sediment load of *chhara* water would be measured by collecting water sample from the *chharas* during water discharge data recording. Standard hydrometer method for measuring the sediment particles of water would be followed for assessing suspended silt carried by flowing water.

iv) ***Intensive Study of Sediment Loading:*** Intensive monitoring would be done on the selected *chharas* to study the intensity of sediment loading and out flow from varying sub-watersheds,. For such intensive study, the sub-watershed might be divided into segments based on the vegetation status and land use. The data would be collected in 3 or 6 hour intervals for a week which would be continued from early to late monsoon i.e. 3 rounds in the monsoon (May to August). The protocol for sediment loading plus the rainfall data collection will be followed for comparative sediment loading study.

v) ***Rainfall:*** Rainfall would be measured for every sub-watershed by setting rain gauge in the sub-watershed area. During sediment monitoring rainfall data would be collected simultaneously with intensive sediment loading data collection.

vi) ***Land Use Survey:*** Land use survey is a very important task for comparative studies of the outflow and sediment load of sub-watersheds because land use variance would make a lot of difference in this particular parameter. Erosion intensity is directly related with land use pattern. Land use survey for each *chhara* will be done using the *Mouza* maps for indicating land use locations.

vii) ***Vegetation Monitoring:*** Regular monitoring is crucial to understand the impact of project intervention on watershed vegetation. This will be accomplished through vegetation survey conducted for keeping track of the floral status and changes in two seasons of the year. Standard methodology will be employed to closely follow the changes in the vegetation.

viii) *Wildlife Monitoring:* Wildlife monitoring will be conducted in the same transect as for vegetation. Wildlife species including birds, mammals, reptilian will be surveyed along assessment of their abundance.

ix) *User's performance monitoring:* The objective is to assess performance of the user/management groups (RMOs) formed locally as a prelude to community participation in the program management and performance monitoring. While the goals and objectives of the project have been clearly set, implementation mechanism designed through people's direct participation and the agreed intervention agenda put to implementation, the project performance is thus directly related to the group performance. Tracking of these group performance will be done through systematic monitoring of the performance against set indicators.

**x. Evaluation :**

Evaluation of the activities implemented under the project would be carried out basing on the baseline data and scenario, and the changes that had taken place through project implementation. In this regard, socio-economic condition, biological production and physical features would be monitored all throughout the project period and on-going as well as 'end of the project' evaluation will be carried out. Fisheries, hill cultivation, forest coverage, riparian and wetland vegetation, wildlife, hydrology and water discharge, sediment loading, and the whole gamut of related aspects would be considered and looked into in the evaluation program.

**xi. Adaptive Management:**

'Learn as you proceed and make changes as needed' is the fundamental concept of adaptive management. This principle will be followed in the implementation of the project programs. The principal tool of adaptive management is systematic monitoring that measures progress over time towards a desired goal. The data and information derived from monitoring of various component activities provides the necessary information to allow the project management to adapt goals and objectives to achievable targets, and cater for unforescen events. Successful implementation of adaptive management will be the primary focus of the project implementing agencies.

**xii. Performance Indicators:**

These are indicators are measurable variables that help to assess changes of parameters over a period of time. A number of five activity indicators have been identified to measure the success of the program. The activity indicators will be matched up with monitoring findings to assess the overall performance.

**xiii. Activity plan:**

Detailed activity plan for a period of 10 years has been included in a tabular form that gives a quick appreciation of what to do and when to do.

## 1. Introduction

The development of *Hail Haor* watershed management plan is supported under the umbrella of MACH project being funded by USAID through Winrock International. The Center for Natural Resource Studies (CNRS) has prepared this plan for integrated development of *Hail Haor* basin and its watershed spreading over the Satgaon, Foyzabad and Balishira hill ranges of the Sreemongol Upozila of Moulvi Bazaar district.

Bangladesh is endowed with an abundance of natural resource and a productive resource base. A deltaic country formed at the confluence of one of the mightiest river systems of the world – the *Ganges*, the *Brahmaputra* and the *Meghna* rivers systems - Bangladesh contains fertile agricultural lands, vast wetlands and rain forests. It has in *Sundarbans* the world's largest mangrove forest and more than 700 km of coastline with the longest sandy sea beach stretching from Cox's Bazaar to Teknaf. The country's aquatic and terrestrial ecosystems support a rich diversity of flora and fauna that provide *inter alia* food, employment and economic benefits to its people. Bangladesh has over 500 fish and crustacean species in its inland and near coastal waters, more than 600 species of birds as parts of its rich biological diversity.

The natural resources of the country have been steadily declining in large part because of development strategies which encouraged a rice mono-culture at the expense of other biological resources. In addition, rising population pressure, rapid urbanization and over-exploitation of natural resources are undermining the environment. The degradation of land and water resources is basically attributed to the increasing pressure on the fragile ecosystems. In the absence of adequate investment and appropriate management practices to conserve and augment the land and water resources of the country, these resources are progressively waning. Increasing population is exerting serious pressure on the ecosystems that prempt overexploitation of natural resources. To alleviate the problems, the strategy should be in the directions that support a process of sustainable development, building on rather than destroying the nation's resources, and should suggest ways and means for making the development process environmentally sound, technically acceptable, socially desirable, and economically feasible.

The landscape of Bangladesh varies in different regions of the country. The northeastern region of the country has a unique undulating landscape formed during the tectonic movement of the continental plateau. In the process, big water bodies with deep depressions have been formed naturally which are locally known as *Haor*. The functionality of the land and water interaction due to slope and gradient of the landmass creates habitats, niches that support wide variety of living beings. *Hail Haor*[1] and its watersheds, situated in the northeastern region of the country, is unique having a distinct hydrological regime that governs the ecosystem of the watershed. *Balishira*, *Satgaon* and Foyzabad hills drain water to this *Haor* through a number of hilly streams and over land flow. The watershed with its range of habitat was a depository of biodiversity. High rainfall, deep tropical forest, riparian vegetation and highly productive wetlands made this part of the country a natural sanctuary for a diverse and productive aquatic and terrestrial flora and fauna. The total area of the watershed is about 56,596 ha with approximately 3,436 ha of wetlands depending on the time of the year.

During the last century, particularly in the last five decades, people have cleared the forests from the hills, hillocks and valleys comprising of the *Haor* watersheds. Clearing of the forests actually started with the invasion of the Tea Growers into the area in 1870. This was followed by people from outside moving into the area who cleared the forest for pineapple cultivation (1950s) and lemon gardening (early 1970s). Clearing of the forests and embarking on steep-slope agricultural cultivation resulted in degradation of the watershed. The soil became exposed and loosened & eroded by rain drop and surface run-off, and eventually washed down by the rainwater and deposited in the *Haor* basin. In this process, nutrient rich topsoil has been lost leaving unfertile substrate in the upper reaches. At the same time increased siltation of the wetlands has resulted in degradation of the wetland habitat in the Haor affecting the fish and fisheries. Forest flora was cleared and fauna losing their habitat could not survive. Destruction of the riparian vegetation resulted in segregated patches of a few remaining

wildlife habitats. The wildlife corridor for movement to different habitants is scarce in the area. Increased runoff and decreased ground water recharge resulted in dry season water scarcity and flash floods during the wet season. The ecological harmony of the watershed has been disrupted. The following table and figure 1 shows distribution of land to different sectoral uses:

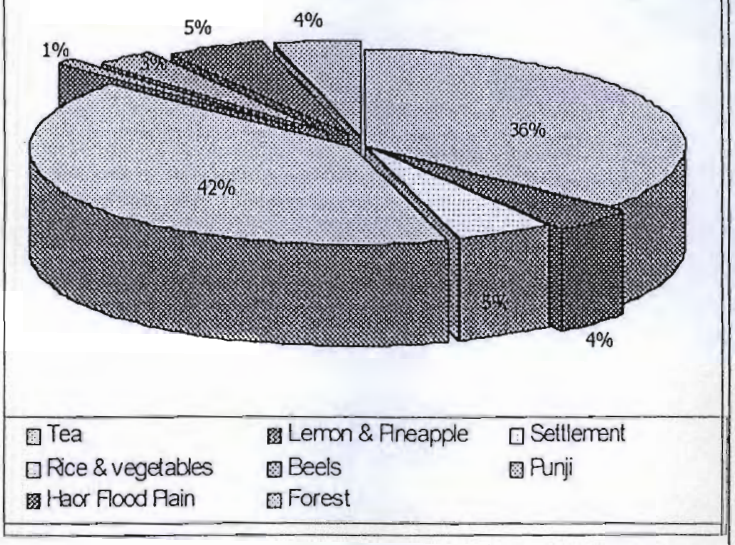



**Figure 1: Percent distribution of Land of *Hail haor* Watershed**

The dry months of the year is the most critical season for all species of fish. During this time, the most significant impacts to fish actually occur. Once migratory species are trapped in the depressions, they become increasingly vulnerable to indiscriminate fishing as the floodwater recedes. Competition for harvesting of wetland resources including fish is keen during this time. Survival of fish in *Beels* and *Haors* during the dry season is directly related to the water level remaining in the depressions. At this time, fishes are exposed to greater predation and increased susceptibility to catch as the water level drops due to water extraction for irrigation and reduced dry season flows from the upper reaches through *Chharas*. Reduction of fish during dry season result in fewer parent stocks remaining to repopulate the Haor in the following year. The reduction could mean stock levels are reduced far below the replaceable limits.

| Types of land use | Area (Ha) |
|---|---|
| Tea | 20633.09 |
| Lemon & Pineapple | 2360.73 |
| Settlement | 2875.00 |
| Rice & vegetables | 23,507.00 |
| *Beels* | 574.00 |
| *Khashia Punji* | 1744.13 |
| *Haor* | 2862.00 |
| Forest | 2404.00 |
| Total Area (Ha) | 56959.95 |

**Table 1: Land Use in *Hail Haor* Watershed (GIS, CNRS, BCAS, Tea Board)**

Social and cultural factors that affect the rural poor of Bangladesh are particularly complex. The issues and problems that affect fisher folks focus on the use of natural resources, in this case *Hail Haor*[1]. The issues and problems are not only related to the use of natural resources but also to the rural poor's relationship to a far broader and often distant social and political system that determines how people interact with the ecosystem and with one another. However complex these issues and problems are, one must first understand them before one can design and implement interventions. The understanding of the socio-cultural, socio-political and environmental issues are of prime importance to the development of appropriate interventions and to plan for sustainable management of watershed resources.

The complex socioeconomic conditions and other interactions of the area having been taken into consideration, a comprehensive problem census/planning workshop model has been used to ensure the participation of the various stakeholders in the preparation of the watershed management plan. Data used in the preparation of this report are the outcome of those planning workshops. Other data sources

[1] *Hail Haor* is located in the northeast region of the country and is an internationally recognized wetland and one of the largest inland freshwater ecosystems in the county (stretch over 15,000 ha in the wet season).

have been the information gathered through conducting surveys, census, using checklist and data forms. Data from secondary sources have also been taken and used.

This report contains the *Hail Haor* watershed management plan including an inventory and analysis of the watershed, problem analysis, priority analysis, micro and macro interventions, goals and objectives of the watershed management, restoration activities, monitoring and evaluation.

## 2. WATERSHED INVENTORY AND ANALYSIS

*Hail Haor* watershed is located primarily in the northeast hill ranges of Bangladesh with some parts in India. The total area of watershed of *Hail haor* is 56,960 ha (CNRS, GIS Unit) in Bangladesh. Bangladesh Water Development Board reported that *Hail haor* watershed area is 60,000 ha of which approximately 85% is in Bangladesh and 15% in India. Due to the undulating landscape and optimum climatic conditions, this area was good habitat for a very diverse nature and abundance of flora and fauna. *Lawachhara* Reserve Forest with am area of about 3440 ha is situated on the eastern side of *Hail haor*. This is one of the important tropical forests of Bangladesh containing a wide range of remaining flora and faunal species. *Hail haor* watershed is now a zone under intensive multi crop cultivation. The upper catchment is covered with forest, pineapple and lemon. The middle reaches of the *Chhara* is mostly under tea and lemon garden, while the lower flood plain and *haor* basin is under paddy and vegetable cultivation with deeper water locations available for fish refuge in the dry season.

As disclosed by the people, till mid 1850s, the entire hilly area under Sylhet district was covered with deep natural forests and diversified wildlife. When the tea gardening business started, approximately 30% of the natural forests were cleared for tea plantation and indigenous people dwelling in the natural forest were forcefully thrown out. Presently, only about 100 *Tripura* families are living within the watershed of *Hail haor*. Conversion of the natural forest into tea garden was the first change made by man. To manage and operate tea estates, laborers were imported from Orissa, Bihar and Assam. To ensure their housing and other living facilities, natural vegetation was cleared and landscapes were changed for cultivation. The tea estate areas of the *Hail haor* watershed is about 20,633 ha.

People from different regions of Bangladesh such as Comilla, Noakhali, Chandpur, and other parts of Bangladesh migrated to Sreemongol to work in the tea estates. Tea estates were the big opportunity for making business as well. Massive hill cutting and deforestation were resorted to in the watersheds by the immigrants. Pineapple and lemon cultivation were started from 1950s. Forests were heavily degraded by the lemon and pineapple farmers. Approximately 4% of *Hail haor* watershed has been converted into mono-culture lemon and pineapple gardens

According to the local communities, there were some 352 *chharas* flowing from the upper catchment into the *Haor*. Degradation of the catchment area and riparian vegetation has resulted in drying out of many and degradation of other *Chharas*. Such degradation also caused dwindling of wildlife as the habitat for wildlife refuge and corridor for their movement had been destroyed. Presently, suitable wildlife habitats are at few and far between and wherever existing, these have become segregated patches of vegetation with limited wildlife shelter, niches and movement.

### 2.1 Biological

Biological diversity or simply bio-diversity is the variety of all forms of life on earth. Its complexity is measured in terms of variations at genetic, species, and ecosystem levels. Bio-diversity plays a critical role in meeting human needs directly while maintaining the ecological processes upon which human survival depends.

The study of *Hail haor* watershed has been done under 3 major land use categories viz., Forests, Managed farming, and wetland areas. The watershed area was subdivided into micro habitats that

included *beels*, streams, rice fields, lemon gardens, tea gardens, rubber plantations, natural forest, planted forest, homestead area and riparian vegetation. These cover all the major wildlife habitat types. The faunal diversity classes considered are Amphibian, Aves, Reptilians and Mammals. The vegetation survey of the watershed has been classified into aquatic, terrestrial and riparian zones, which again fall under the microhabitats mentioned eaarlier. In the surveys, 3 transects were drawn covering all the microhabitats that in turn cover the watershed land use categories. A riparian vegetation survey was also conducted to understand the plant species diversity and composition (tall trees, medium trees, shrubs, herbaceous cover and emergent vegetation) growing along *Chhara* bank and terrace.

### 2.1.1 Wildlife

To analyze the wildlife of *Hail Haor* watershed, a survey considering different seasons have been conducted drawing transects including different habitats. The survey has been conducted during both wet and dry season. Data were collected by field observation and through interviews of the resource users (fishers, boatman, forest wood collectors, villagers and interested citizens).

Among the diverse wildlife, amphibians, reptiles, birds and mammals species have been recorded. A total of 129 wildlife species have been observed including 5 amphibious, 17 reptiles, 88 birds and 19 mammals species during wet season while a total of 97 wildlife including 5 amphibians, 18 reptiles, 17 mammals and 57 birds have been observed during dry season (Annex-1). Round the year a cumulative total of 164 species of wildlife have been recorded. It is worth mentioning that distributions of wildlife, except amphibians, are highest in the transitional zone between forest and *Hail haor* basin.

Common toad (*Buto melanostictus*) and Skipper Frog (*Rana cyanophlyctis*) were abundant. Tree Frog (*Rana temporalis*) were not widely distributed. Population of Bull Frog were found in good distribution.

Occurrence of Rock Python (*Python mulurus*) has been reported in the forest by a local forest official. Checkered Keelback (*Xenochro piscator*) and Olive Keelback (*Atretium schistosum)* were common. Common Skink *(Mabuya carinata)* and Garden Lizard *(Calotes versicolor)* were common whilst Wall Lizard *(Gekko gecko)* were rare.

Emerald Dove *(Chalcochaps indica)* has been seen during dawn. Like some parts of Cox's Bazaar Forest, an acceptable number of Redwhiskered Bulbul *(Pycnonotus jocosus)* has been observed at *Lauachhara* forest. There were no migratory ANATIDAE species. Some Little Grebe *(Podiceps ruficollis)* has been observed in the *Beel* area of *Hail haor*. Redvented Bulbul *(Pycnonotus cafer)*, Crow Pheasant *(Centropus sinensis)*, Koel *(Eudynamys scolopacea)*, Baya *(Ploceus philippinus)*, Whitebreasted Waterhen *(Amaurornis phoenicurus)*, Pond Heron *(Ardeola grayii)*, Cattle Egret (*Bubulcus ibis*), Little Egret (*Egretta garzetta*) are Bronzwinged Jacana (*Metopidius indicus*) were common. The population size of Purpierumped sunbird (Nectarinia zeylonica), Purple Sunbird *(Nectarinia asiatica*) and Little Spiderhunter (*Arachnothera langirostris*) were in good abundance and distribution. Nests of some uncommon birds like Hill Myna (*Gracula religiosa*), Greater Rackettailed Drongo (*Dicrurus paradiseus*) has been found.

A baby Fishing Cat (*Felis viverrina*) has been seen in a cave like structure near *Lawachhara* Forest Rest House where huge wood logs were accumulated. Record of the existence of this threatened species has proven that still *Lauachhara* forest is good habitat for *mammals*. One of the most rare mammalian PONGIDAE species Hoolock Gibbon (*Hylobates hoolock*) has been seen in the upper canopy zone of the forest. Jackal (*canis oureus*), Begal Fox (*vulpes bengalensis*), large Civet *(Viverra zibetha*) and Small Civet (*Viverricula indica*) are in threatening condition due to habitat destruction in the lower watershed area (*haor* basin). A troop of Rhesus Macaque (*Macaca mulata*) has been observed feeding near Nurjahan Tea Estate.

Deforestation, agricultural extension, conversion of habitat, siltation in water bodies, loss of water connectivity, construction of dams & dikes for stream control, dewatering of *beels* and canals for fish harvest are major causes of habitat degradation for wildlife, birds and aquatic animals and vegetation. Along with habitat degradation illegal hunting of birds and light fishing are also cause a of reduction of migratory birds in *Hail haor*. Unwise use of agro-chemicals like- pesticides, herbicides in the upper watershed by the tea and lemon planters are causing death and diseases for aquatic wildlife of the *haor*.

### 2.1.2 Vegetation

Vegetation survey has been conducted covering the entire watershed i.e. both for aquatic and terrestrial ecosystems during both wet and dry season to get the baseline status of vegetation. The impact of plantation or vegetation conservation program would be assessed by the vegetation survey that has been/would be conducted by MACH-Project, Sreemongol site.

On the basis of 8 habitat types, 3 transects were demarcated. The habitat types are *Beel*, paddy field, natural forests, plantation forests, homestead area, Lemon garden, Tea garden and Rubber plantation. Transect-1 (Boulashir, where a *Bot* and *Tomal* tree are present near to *Laler doba*) is for aquatic vegetation. Transect-2 (Finlay Tea garden, Foyzabad to Abdus Sattar's Palm tree of Bhunobir village) and transect-3 (BTRI Road to East of DFID) are for watershed vegetation. Two transects for riparian vegetation were studied; these are, Transect-I (North bank of Joita Chhora) and Transect-II (South bank of Joita Chhora). For both the transects, the starting point is the metalled road and ending points is Hasan Ali's home.

Quadrate method was applied in this survey. 10 quadrates were studied in each transect. Quadrates were 2x2 $m^2$ in size and distance from one to the other was 230 m for transect 1. For transect 2 and 3, the quadrate size was 16 $m^2$ and the distances between two successive quadrates were 500 and 200 m respectively. For terrestrial riparian vegetation, 10 quadrates were studied from each transect. Quadrates size was 4x4 $m^2$ and the distance between two successive quadrates was 100 m. Terrestrial vegetation surveys focused only on shrubs, trees and tree like vegetation. Plants that were artificially planted to regenerate riparian vegetation by the project were not counted.

The total number of individual plant species, their density, frequency and abundance were calculated transect wise. The total number of each species when divided by the total number of quadrates where vegetation was studied, equals the average density of vegetation species found. Frequency is number of quadrates where species occurs divided by the total number of quadrate within transect. Abundance is the total number of an individuals divided by the number of quadrates where the species occur. Relative density, frequency and abundance of vegetation species are determined when individual density, frequency, and abundance are divided with total number.

The vegetation survey indicates that there are 107 species of aquatic vegetation in the lower watershed of *Hail haor*. Out of 107 species, 84 and 85 species were observed during dry and wet season respectively (Annex-2). At present Hydrilla, *Shapla, Jhoradhan, Aroil, Bicha shaola, kata shaola pata shaola, Futki* are dominant in *Hail Haor* basin. The settlement area has a wide range of vegetation species. There are 55 terrestrial vegetation species covering settlements and hilly areas. A total of 12 species of vegetation have been found in the riparian zone. Zaibansh (*Bambusa valgaris*), a type of domesticated bamboo, is widely distributed along the *chhara* bank, both planted and natural.

Another riparian vegetation survey was also conducted to understand the population of vegetation (tall trees, shrubs, herbaceous cover and emergent vegetation) growing along *Chhara* bank and terrace (Annex-2a). The middle reach of Jaita *Chhara* (metalled road to Tea road) was selected as the monitoring site. A number of 23 transects were selected along each bank of *Chhara* maintaining a systematic distance of 100m within transect. Canopy density of tall trees was measured with

densiometer while shrubs, herbaceous and emergent vegetation density was measured with eye estimation. Height of tree bole, shrubs, herbaceous cover was also recorded through observation.

Riparian vegetation survey of Jaita *chhara* middle reach (Table 2) shows that 32% of riparian zone of north bank is covered with tree canopy of which the species are mostly bamboos, and that is why bole height of trees is comparatively lower (1.5 M). Table 2 also shows that 58% of *chhara* area is covered with herbs, while woody shrubs cover only 16%. Shore protective emergent vegetation ranges from 50-53%, it indicates that half of the shore is unprotected from water erosion.

**Table 2 : Riparian vegetation of middle reach of Jaita *Chhara* (Paved road to Tea estate road)**

| North Bank of *Jaita chhara* Middle Reach | | | |
|---|---|---|---|
| Types of Vegetation | % canopy cover | Height (m) | Bole Height (m) |
| Tree | 32 | 8 | 1.5 |
| Woody Shrubs | 16 | 0.4 | - |
| Herbaceous cover | 58 | 0.17 | - |
| Open water Emergent Vegetation | 7 | - | - |
| Shoreline emergent vegetation | 53 | | |
| South Bank of *Jaita chhara* Middle Reach | | | |
| Tree | 23 | 7 | 1.3 |
| Woody Shrubs | 22 | 0.8 | - |
| Herbaceous cover | 60 | 0.12 | - |
| Open water Emergent Vegetation | 11 | - | - |
| Shoreline emergent vegetation | 50 | - | - |

### 2.1.3 Fisheries

The Hail *Haor* watershed area is 56,960 ha. of which 3436 ha is depressed basin. This includes 574 ha. of *beel* area (131 *beels*). There are 64 villages around the *Haor* basin. The people around the *Haor* are dependent on the *Haor* resources particularly fishes for their protein source and means of livelihood as well. The fishery of the Hail *Haor* was very rich both in species diversity and abundance. Due to natural and anthropogenic causes, the fisheries resources of Hail Haor are declining. By far the biggest factor has been the land use practices which have severely degraded the watershed feeding the Haor. The degradation has caused imbalance to a 100s of watershed functions resulting in a very rapid sedimentation of the Haor. There are now fewer habitats for fish and the area is rapidly decreasing. There is a lot of room to conserve and enhance the resources through appropriate interventions and management. A comprehensive fish catch assessment has been conducted by CNRS-MACH from April 1999 to March 2000 and serves as the baseline for the *Haor* fisheries.

**Table 3: Percentage Distribution of the Gears observed inside Hail Haor**

| Name of the Gear | Total Observed | |
|---|---|---|
| | Number | Percentage |
| Veshal Jal | 206 | 0.03 |
| Ber Jal | 152 | 0.02 |
| Current Jal | 27946 | 3.87 |
| Thela Jal | 775 | 0.11 |
| Traps | 16999 | 2.35 |
| Hooks | 675780 | 93.59 |
| Others | 171 | 0.02 |

In order to ensure spatial and habitat representation, catch and effort data have been collected from 9 (nine) sample geographical locations having different types of water bodies/habitats (beels, canals, Rivers and floodplains) within the *Haor* to estimate fisheries parameters. A total of 13 gears have been observed in fishing. There are professional fisher (who fish through out the year), part time professional (Fish for a period of the year) and subsistence fisher (Fish for consumption). Among the gears observed, 6 types were found common compared to others (Table 3).

The species richness of the monitoring locations ($\alpha$ diversity) and fish species richness within the Hail Haor ($\beta$ diversity) has been observed and recorded. The $\alpha$ diversity varies among the locations and the $\beta$ diversity for Hail Haor, and the overall was 68 during the monitoring year (Table 4). CPUA varies in different locations and for Hail Haor was 163.95 Kg./ha/year (weighted average) ( Table 4).

**Table 4: Species Richness and CPUA of different locations of Hail Haor**

| Location | Species Richness | CPUA |
|---|---|---|
| Jethua Beel | 37 | 112.80 |
| Gopla River | 53 | 393.64 |
| Boulashir Floodplain | 50 | 69.82 |
| Cheruadubi Beel | 39 | 278.31 |
| 62 Beels | 55 | 140.39 |
| Alni Beri Beel | 39 | 248.12 |
| Rustompur | 49 | 158.87 |
| Balla Beel | 39 | 35.57 |
| *Overall* /weighted avg. | *68* | *163.95* |

## 2.2 Physical

### *2.2.1 Geology*

The relief of the Sylhet basin is governed by the axes of the Tertiary sedimentary formations. The hill

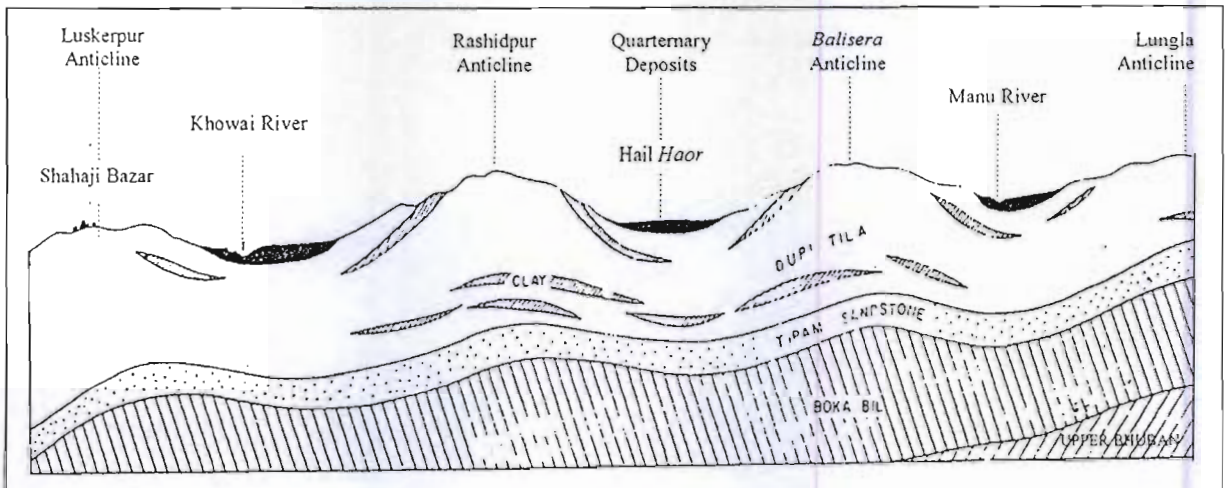



**Figure 2: Diagrammatic Geological section from East of Monu River to Shahajibazar**

ranges are in the form of anticlinal ridges. Watersheds coincide with anticlinal axes. Flanking the ridges along most of their lengths, the outcrops of the highest tertiary formation form apron zones of gently sloping and undulating land. Between the ridges are wide and shallow valleys occupied by recent alluvium of the floodplains of major rivers merging with the out wash alluvium of the tributary streams draining the ridges. A diagrammatic geological section of the watershed area is given in figure 2. The height and steep ness of the ridges are to a great extent dependent on the intensity of the folding.

The drainage pattern of ridges is largely consequent and dendritic, the lateral streams joining the major tributaries of the Surma-Kushiyara system in the Haor basin. The effect of intense monsoon rainfall on hill lands of relatively unconsolidated material is the loss of considerable topsoil resulting from erosions. The erosion is accelerated by unscientific conversion of hilly land and deforestation. Soils on slope are progressively truncated, soil creep takes place and exposed sections and hillsides are liable to slump. Valleys are steep sided. Soil weathering is intense and oxidation and disintegration of parent rock can occur to a considerable depth.

Figure 2 shows that the deep basin of the *Hail haor* watershed consists of Quartenary deposits while soils of upper catchment originate mainly from underlying *Tipam* series.

**Table 5: Stratigraphy of Tertiary and Quarternary Sediments in Assam**

| Age | Formation | Lithology | Thickness |
|---|---|---|---|
| Quarternary | *Undifferentiated* | Stream, interstream and piedmont deposits | - |
| Pliocene | *Dihing Series* | Sands with gravel beds | 0 to 5,000 ft |
| Mio-Pliocene | *Tipam Series* | | |
| | Upper Dupi Tila | Vari-coloured sands and clays, sandy clays and cleyey sands in alternating bands. | Approx. 6000 ft. |
| | Lower Dupi Tila | Sands, fairly coarse grained in the north, finer grained towards south and west with occasional clay layers | Do |
| | Giruzan Clay | Clay, sandy and clayey sand with beds of sand | 0 to 5,000 ft. |
| | Tipam Sandstone | Ferruginous sands and sandstones with beds and tings of shale | 3,000 to 5,000 ft. |
| Oligo-Miocene | *Surma Series* | | |
| | Boka Bil | Shales and laminated silts with intercallations of sand and sandstone | 2,000 to 5,000 ft. |
| | Upper Bhuban | Shales and sandstones in alternating bands | 2,000 to 3,000 ft. |

Table 5 shows that the lithology underlying the *Hail haor* watershed includes sand and sandstone. Tipam series consists of Dupi Tila and Tipam sandstone mainly. Quaternary deposits are marked within the valley of hill and depressed area of watershed.

Only the *Dupi Tila* Tertiary formation is considered a good aquifer for installation of large capacity irrigation wells. Table 5 shows that it is approximately 6,000 ft thick. All other strata are poor aquifers because they are either more strongly cemented or contain a large portion of silt and clay. Some part of the tertiary strata shows high degree of deformation. Steep folding with vertical dips in places and some major faulting. In such areas ground water exploitation by deep wells is not feasible because the folding and faulting has created barriers which will impede horizontal ground water flow.

Source: Report Investigation into Irrigating Tea in Sylhet and Chittagong Districts (Hunting Report, James Finlay PLC)

### 2.2.2 Landscape

The topography of the north-eastern part of Bangladesh is uneven. Hills surround the *Hail Haor* basin to the west, east and north. Approximately 50% of the watershed area is hilly and managed by different tea estates, lemon-pineapple garden owners and the State Forest Department. People are converting the landscape by cutting hills for different patterns of agricultural farming and also for making roads and establishing human settlements. Continuous and shifting cultivation on the hills and steep slopes are causing severe erosion and landslides, which are also responsible for changing landscapes of the watershed. The elevation of hilltops ranges from 60 to 66 meter above mean sea level (MSL) while the base of the hills range from 25 to 35 meter; and wetland basin itself is in the range of 2-6 m above MSL.

### 2.2.3 Soil

The land of *Hail haor* watershed is subdivided into three land types viz., Hilly land, Piedmont alluvial area and Surma-Kushiyara floodplains. Hilly areas comprise the hills of *Satgaon, Balishira* and *Faizabad*. Piedmont alluvial area comprises the high flat of the south and east part of *Hail haor* occupying some 11,320 ha area. Surma-Kushiyara floodplain is the *haor* basin comprises of 7,229 ha area (included areas outside the Hail Haor basin).

To study the nutrient contents of soil and the impact of erosion on soil quality, 10 soil samples were collected from different topography and locations of *Hail haor* watershed (Annex-4). The soil samples were analyzed for various parameters including nutrients contents. The pH of surface soil is acidic in nature and range from 4.7-5.2. Soil pH is low probably due to higher contents of iron and manganese that combines with water and forms hydroxyl ions of Fe & Mn and also free $OH^-$ ions.

Nutrient contents of soil are low. The concentration of Mn and Fe are very high in the soil. It is seen from the analysis result that soil qualities of pineapple gardens are worse as compare to soil of lemon gardens. This is what is expected because of the provocative 'across the contour' pineapple cultivation practiced by the growers that washed down the fertile top soil and nutrient. Fertilizers especially N, P & K are applied by most of lemon farmers. That is why some of these nutrients are found in medium to optimum levels. The sampling has been conducted maintaining standard protocol and analysis, and was done in the Soil Research Laboratory of BTRI, (Bangladesh Tea Research Institute), Sreemongol.

Soil texture and structure of *Hail haor* watershed varies according to the topography. The surface soils of hilly areas are sandy, sandy loam and clay loam in texture, while the soils of high flat lands are mainly loam and clay loam. Texture of *Hail haor* flood plain is mainly clay and clay loam.

### 2.2.4 Chhara (Stream)

Streams flowing from the upper catchment to the lower catchment locally called *Chhara* which drains water to *Hail haor*. According to people of the area, 352 *Chharas* previously flowed into the *haor* from the watershed. Presently a total of 59 *Chharas* have been found by inventory that feed the *Hail haor*. All the *Chharas* that are feeding *Hail haor* originate from the hills of Sreemongol, Bahubal, and Kamalgonj Upazilas namely- *Balishira*, *Satgaon* and *Faizabad* hills. Water flowing through *Chharas* varies in quantity and quality, as their upper catchment are different. Table 6 shows the list of stream, their origin, length of main trunk and number of tributaries and their length.

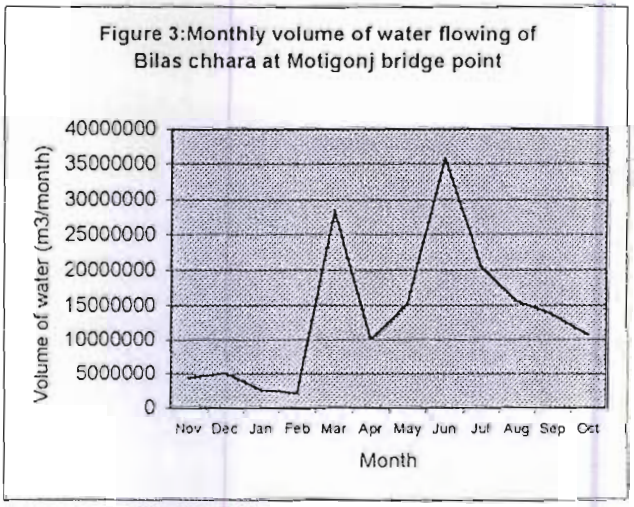
Table 6: List of streams and source including the length

| Sl. No. | Name of Chhara | Name of Source Hill | M Stream Length(m) | No of Tributaries | Tributaries Length (m) |
|---|---|---|---|---|---|
| 1 | Kalni/Raypan Chhara | *Satgaon* | 3235 | | |
| 2 | Bangua Chhara | *Satgaon* | 4725 | 3 | 4993 |
| 3 | Pagri Chhara | *Satgaon* | 1365 | 4 | 965 |
| 4 | Pagla Chhara | *Satgaon* | 2044 | 8 | 2169 |
| 5 | Bar Chhara | *Satgaon* | 5366 | 4 | 8125 |
| 7 | Chang Chhari | *Satgaon* | 1764 | | |
| 8 | Kaila Chhara | *Satgaon* | 4822 | | |
| 9 | Taka Chhara | *Satgaon* | 1436 | | |
| 10 | Jaulam Chhara | *Satgaon* | 5378 | 2 | 3820 |
| 11 | Duma Chhara | *Satgaon* | 1044 | | |
| 12 | Kali Chhara | *Satgaon* | 3092 | | |
| 13 | Mura Chhara | *Satgaon* | 4884 | 2 | 1780 |
| 14 | Boula Chhara | *Satgaon* | 7045 | | |
| 15 | Gandarbpur Chhara | *Satgaon* | 2461 | | |
| 16 | Haira Chhara | *Satgaon* | 3548 | | |
| 17 | Burchungi Chhara | *Satgaon* | 4726 | 2 | 1284 |
| 18 | Ichhamati Chhara | *Satgaon* | 7925 | 9 | 6535 |
| 19 | Nauli Chhara | *Satgaon* | 3311 | | |
| 20 | Andhi Chhara18 | *Satgaon* | 4774 | 4 | 2132 |
| 21 | Jaita | *Satgaon* | 7595 | 2 | 3259 |
| 22 | Maura Gung | *Faizabad* | 2450 | | |
| 23 | Patri Chhara | *Faizabad* | 4644 | 1 | 1468 |
| 24 | Sharia Chhara | *Faizabad* | 5187 | 1 | 1360 |
| 25 | Makri chhara | *Faizabad* | 5612 | | |
| 26 | *Alia* Chhara | *Faizabad* | 8806 | 4 | 7103 |
| 27 | Kodali Gung | *Faizabad* | 13712 | | |
| 28 | Bilas Chhara | *Balisera* | 23544 | 4 | 11137 |
| 29 | Fulchhari Chhara | *Balisera* | 12238 | 2 | 4956 |
| 30 | Kaikka Chhara | *Balisera* | 9450 | | |
| 31 | Burburi Chhara | *Balisera* | 12467 | 2 | 8545 |
| 32 | Shakhamora Chhara | *Balisera* | 7122 | | |
| 33 | Dablechhari Chhara | *Balisera* | 7333 | | |
| 34 | Jainkha Chhara | *Balisera* | 9709 | | |
| 35 | Badeswari Chhara | *Balisera* | 2647 | | |
| 36 | Khai chhara | *Balisera* | 5883 | 2 | 3172 |
| 37 | Jaag chhara | *Balisera* | 9873 | 4 | 7587 |
| 38 | Akali Chhara | *Balisera* | 1035 | | |
| 39 | Kalk*Alia* Chhara | *Balisera* | 6095 | | |
| 40 | Kakia Chhara | *Balisera* | 1825 | | |
| 42 | Chang Chhara | *Balisera* | 5931 | 2 | 3775 |
| 43 | Sonai Chhara | *Balisera* | 1770 | | |
| 44 | Dudchhari Gung | *Balisera* | 1723 | | |
| 45 | Maurashaon Chhara | *Balisera* | 2011 | | |
| 46 | Shaon chhara | *Balisera* | 5593 | | |
| 47 | Shial Chhara | *Balisera* | 6036 | 3 | 1827 |
| 49 | Narayan Chhara | *Balisera* | 1880 | | |
| 51 | Dangdingi Chhara | *Balisera* | 4082 | | |
| 52 | Gabur Chhara | *Balisera* | 6735 | 2 | 3512 |
| 53 | Moura Chhara | *Balisera* | 3998 | | |

| Sl. No. | Name of Chhara | Name of Source Hill | M Stream Length(m) | No of Tributaries | Tributaries Length (m) |
|---|---|---|---|---|---|
| 55 | Dewa Chhara | *Balisera* | 5460 | | |
| 57 | Dudchhari Chhara | *Balisera* | 3557 | | |
| 58 | Meghna Chhara | *Balisera* | 2729 | 1 | 1193 |
| 59 | Kodali Chhara Gung | *Balisera* | 6277 | | |
| *Total* | | | *287954* | | *90697* |
| **Following are the important tributaries that meet with Bilas** | | | | | |
| 1 | Barma Chhara | | 24431 | 3 | 31199 |
| 2 | Udna Chhara | | 32632 | 3 | 22921 |
| 3 | *Laingla* c. | | 11743 | 1 | 7751 |
| | *Total* | | *68806* | *7* | *61871* |

26 *Chharas* (the first 26 of the table) flow from the West to East, 2 *Chharas* from North to South and the remaining 31 are from East to West.

Among the 59 *Chharas*, a few *Chharas* viz., Bilas, *Alia*, Jaita, Shaon and Jaag *Chhara* supply the bulk of water to the haor. A few important ones of these chharas are dealt hereunder in some greater details.




a. Bilas *Chhara* : This *chhara* carries the highest volume of water in the *Hail haor* watershed. It originates from the hills of India and enters into Bangladesh in the vicinity of the *Tripura* tribal village near the BTRI research tea garden under Sreemongol Upazila. The watershed area of this *Chhara* is 12,597 ha and out flow of water varies with varying precipitation. In the Motigonj bridge point the average water discharge is 5.24 $m^3$/sec during dry season (October-March) and 9.22 $m^3$/sec during Wet season (April-September). The watershed of Bilas *Chhara* is covered mostly by tea garden and paddy field. Near Tikria village, Bilas *Chhara* enters into flat paddy fields. The gradient is <15% in the tea garden area and <5% in the flat paddy lands. Flat paddy areas are vulnerable to flash floods during the monsoon as this area is dammed by the railway and Dhaka-Sylhet highway. Bilas falls into the *Haor* after passing 2 kms from Dhaka- Sylhet road. This land is submersible during monsoon (June to October). Crops are not cultivated during this period. Only *Boro* is grown in this land during the dry season (January to May).

*Bilas Chhara* is a cumulative channel of *Udna, Laingla, Borma, Chalta, Dengdinga, Putia, Harpa, Aam* and many small tributaries. It is calculated that over 37% water of Hail haor is coming through the Bilas *chhara* throughout the year. According to data from the Water Development Board of Bangladesh, about 50% of total watershed area of *Hail haor* belongs to Bilas *Chhara*. The *chhara* is a source of natural resources mainly water and sand. Sands are extracted from four points of the Bilas which are leased out from the Ministry of Mining, Dhaka. According to sand miners about 40,00,000 sq. ft of sands were extracted during the last year (April, 1999-April, 2000). Of this, 90% during the wet season and 10% in dry season. Due to constructed cross dams to supply irrigation water in many areas, dry season sand mining is not possible.

Important tributaries of Bilas *Chhara* have been inventoried and GPS readings were taken as well, to incorporate with the landsat and IRS images.

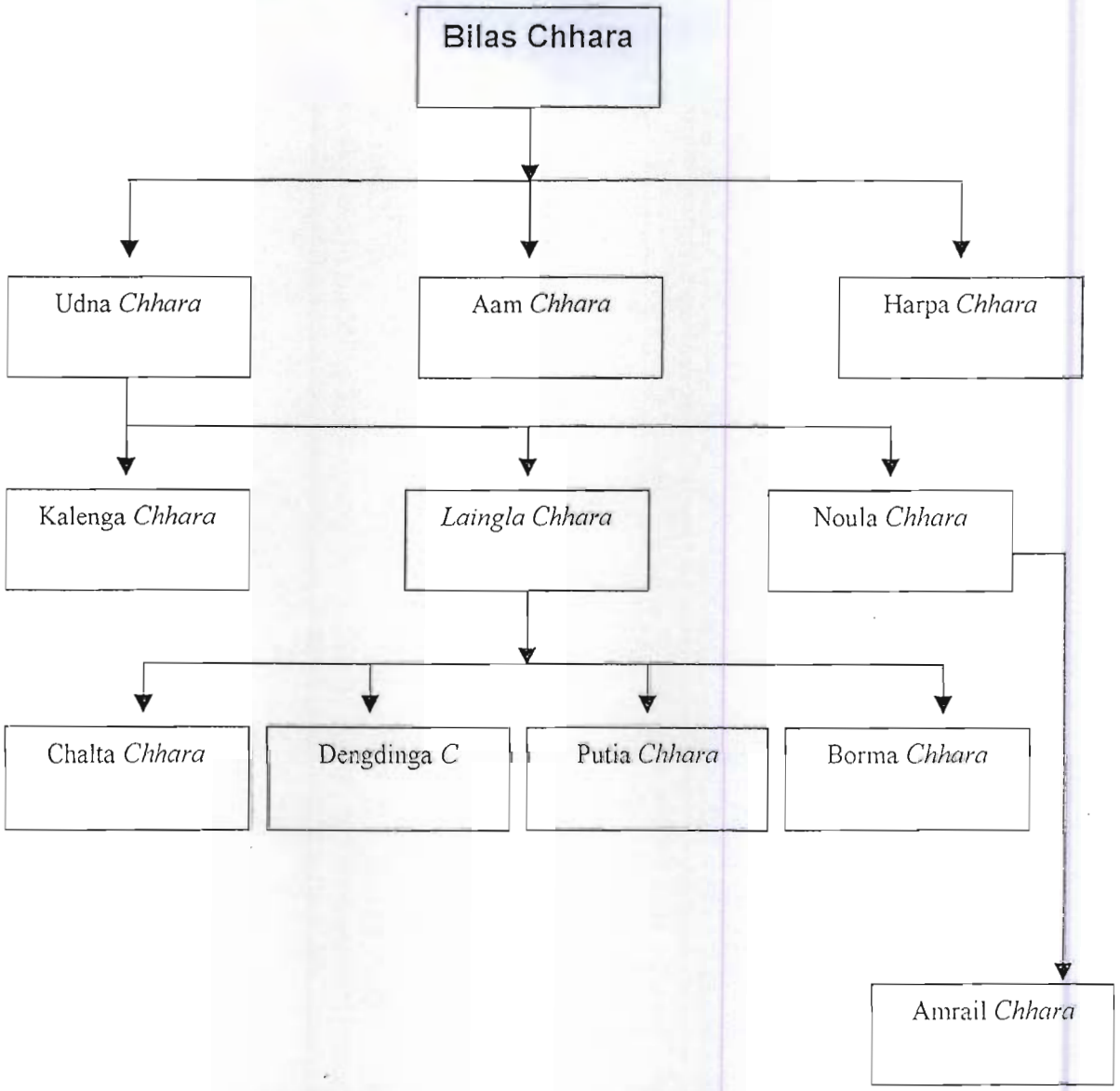
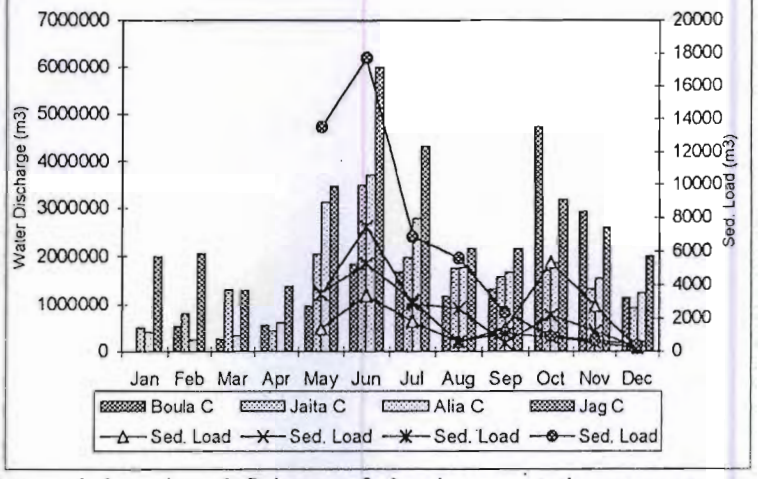



Figure 4: Shows the connectivity and tributaries of Bilas *Chhara*

b. **Jaita *Chhara*:** Jaita *chhara* carries water flows higher than other *charas* draining from the *Faizabad-Satgaon* hills. Originating from the *Faizabad* tea garden crosses 2 km within the lemon & pineapple gardens of *Faizabad* hills. 2 streams of about same size met together in the lemon & pineapple garden of *Faizabad* hills and then flowing towards the *haors*. Lemon and pineapple garden management system enhances soil erosion, land sliding and landscape changes of watershed. The south part of the upper catchment is covered with Reserve Forest and natural sungrass. Average channel gradient for Jaita *Chhara* upstream at lemon & tea garden and metalled road areas are 1.22%, 0.3% and 0.2% respectively (Interim Hydrology Report, September 7, 2000). After crossing the *Faizabad* hills, it enters into the flat lands of West Bhunabir under Sreemangal Upazila. The catchment area of this reach is covered with newly established lemon gardens, seasonal vegetables and paddy fields. The *chhara* bank condition is degraded due to soil erosion and there is a deficiency of riparian vegetation coverage. After crossing the metalled road and adjacent settlements, the *chhara* falls into *haor* basin. This land is usually submerges during monsoon (June to October) when of course no crop is cultivated. Only *Boro* paddy is grown in this land during dry season (January to May).

Figure 5: Water discharge & Sediment loading relation of chhara




c. ***Jaag Chhara*:** *Jaag* has one of the highest flows among the *Chharas* of *Balisghira*-Lawachhara hills. Originating from the Lawa *Chhara* reserve forest, it crosses about 4 kms of tea garden belonging to James Finlay. Two streams of about the same size meet upstream of the tea garden and then flow into the *haor*. Average channel gradient in the top stream is 0.8% while 0.2% & 0.15% near metalled road and haor respectively. After crossing the Tea garden, it enters into flat lands of Noagaon-Yousufpur. The command area of this chhara reach has paddy fields but mostly settlements. The bank condition of the *Chhara* is degraded. In the tea garden area the slope of the bank is steep and within the village the *haor* bank sloped moderately. After crossing the metalled road and subsequent settlements, the *chhara* falls into the *haor*. The catchment area of Jaag within the *haor* is submerged with water during monsoon (June to October). Crops are of course not cultivated during this period. Only *Boro* rice is grown in this land during the dry season (January to May).

To assess the annual and seasonal water discharge through *Chharas*, silt and sediment load is being observed at week's interval. A total of 22 *Chharas* of different sizes and water flowing capacity have been selected for the study based on the watershed categories. The different watershed categories are forest, tea garden, lemon and pineapple garden and paddy fields etc.

## 2.3 Infrastructure

In order to accommodate the increasing population (migrating from the plain), the area has been infrastructurally developed. The increasing population required more space for settlement and land for agriculture. The excessive pressure on land has nearly eliminated natural forests habitat from this watershed. The cumulative effect of shifts has resulted in the ecological change within the watershed.

*Hail haor* watershed area continues to degrade. Most of the upper catchment is covered with tea garden, paddy, lemon & pineapple, vegetables and settlements with poor land management. In order to accommodate the increasing population and enhance agriculture, the houses, roads, embankments/dams, sluice gates etc. are created and these infrastructures are responsible for ecological changes of the watershed.

### *2.3.1 Tribal Settlements*

Within the 56,960 ha watershed area of *Hail haor,* about 5% is covered with settlements. The settlements in the upper Catchment have been developed basing on the stream availability. For example, *Alia punji*, Nirala *punji*, Nehar *punji* have been developed by the side of *Alia* and *Laingla Chhara*.

Tribals such as the *Khasias* and *Monipuris* in this tract, choose their settlement sites on top of the hills on hygienic reasons. Over 1000 ha of land in *Hail Haor* watershed is occupied by the tribal *punji* viz., *Alia*, Nirala, Nehar, *Laingla*, and Hosnabad *punji*. About 10-15% of the lands are occupied for housing, schooling and temple/church. Every *Punji* is administered by a *Mantri* (Headman) who obtains land lease from the Government, and controls and regulates land distribution to *Punji* families.. Beetle leaf, beetle nut, jack fruit, black pepper are the main crops of *khasia* though lemon and pineapples are grown at *Alia punji*. Table 7 shows the land holding status and cropping pattern of indigenous community in the watershed.

Table 7: *Khasia* settlements and cropland

| Name of *Punji* | Ownership | Area (Acres) | Name of *Chhara* near to *Punji* | Cultivated crops |
|---|---|---|---|---|
| *Alia* | Lease & private | 475 | *Alia Chhara*, Kalia *Chhara* | Beetle leaf, Beetle nut, Jack fruits, *Gol marich*, Lemon, Pineapple |
| Nirala | Applied for lease | 860 | *Laingla Chhara* and tributaries | Beetle leaf, Beetle nut, Jack fruits, *Gol marich* |
| Nahar | Nahar tea garden | 300 | *Laingla Chhara* | Beetle leaf, Beetle nut, Jack fruits, *Gol marich* |
| *Laingla*sera | Applied for lease | 238 | *Laingla Chhara* | Beetle leaf, Beetle nut, Jack fruits, *Gol marich* |
| Hosnabad | Hosnabad tea garden | 300 | Harpa *Chhara* | Beetle leaf, Beetle nut, Jack fruits, *Gol marich* |
| Lawasera | Forest Department | 200 | Lawachhara, Jaag *Chhara*, | Beetle leaf, Beetle nut, *Gol marich* |
| Total | | 2373 | | |

### 2.3.2 Roads

There are four FRB (Feeder Road, type B) roads in the *Hail haor* watershed connecting growth centers as follows

- Dobarhat
- Sindurkhan
- *Satgaon* Rail Station, and
- Kejurichhara Bazar

Besides the FRB, there are different types of roads in the area including the national Highway. These are depicted in Table 8.

Excluding the National Highways and FRB, there are three categories of rural roads viz.,

a. Rural Road, Type-A ($R_1$ road) : This category is a secondary connection between growth centers and important village market, industry etc. Table 8 shows that about 87 km $R_1$ road exists in this watershed which are summation of 17 roads of type $R_1$.
b. Rural Road, Type-B ($R_2$ road) : Roads which are connected between bazar to bazar or bazar to village i.e. roads that connect important places of village. These roads may be metalled (bituminous carpetted), earthen or brick soled. Table 16 showing a total of 58 km $R_2$ type roads are found within *Hail haor* watershed.
c. Rural Road, Type-C ($R_3$ road) : Roads which are connected between bazar to bazar or small bazar to village and generally small in length and width are categorized as $R_3$. These roads are earthen. Table 8 showing 53 numbers of $R_3$ type road makes about 115.24 km length within *Hail haor* watershed.

**Table 8: Distribution of different categories roads within the watershed of *Hail haor***

| Road's category | Type | Length by different types (km) | Length (km) | Nos. of Bridge & Culvert | Cumulative Length (m) |
|---|---|---|---|---|---|
| National High Way | Paved | 32 | 32 | 25 | 500 |
| Feeder Type-B | Paved | 44 | 44 | 129 | 734.4 |
| Rural Road type-A (R1) | Paved | 28.6 | 86.41 | 112 | 560.8 |
| | Brick soling | 2.71 | | | |
| | Earthen | 55.1 | | | |
| Rural Road type-B (R2) | Paved | 0 | 216.45 | 130 | 490.5 |
| | Brick soling | 2.95 | | | |
| | Earthen | 213.5 | | | |
| Rural Road type-C (R3) | Earthen | 115.24 | 115.24 | 56 | 168.5 |
| Grand Total | | | 494.1 | 452 | 2454.2 |

Roads running across the chhara flow direction impede water flow from upstream to down stream. Water on occasion can't flow through the *Chhara* after a heavy rainfall due to constriction caused by narrow bridges and culverts. The Dhaka-Sylhet Highway crosses the watershed along the North & East upstream of *Hail haor* while the West & South sides are encircled by feeder road type-B from Bhunabir-Shomshergonj and Shomshergonj-Moulvibazar road respectively. These roads obstruct water flow at times of flood due to their elevation above general ground level.

The north side of *Hail haor* is also crossed by Dhaka - Sylhet railway road. Most roads are 2-4 meters higher than the surface level of agricultural fields resulting in obstructed drainage of rain water and

flooding after heavy rainfall. During floods, coarse sand coming with the water is deposited on the crop lands and cause infertility of soil.

### 2.3.3 Dams/Embankments

Dams and embankments are mainly established to store water upstream of the *Hail haor* wetland. The lakes and ponds are usually constructed to ensure irrigation water for tea estates especially to newly planted garden and nurseries during the dry season. The tea estate authorities believe that the lakes are good for creating cool environment for tea as well as for water retention in the watershed .

*Photo 1: Dam in the upstream of chhara during dry season*

There are 7 such lakes/ponds within watershed area of *Hail haor* established by the tea estates. These lakes are situated at the Huglishira, Daragaon, Baroora, Rajghat, Bilaschhara, Majdehee and Moulvi tea garden. The total area of the lakes are over 34 ha. The size of the dams may be of varied length but the width at the bottom & top of dam is about 70 ft & 16 ft respectively.

Seasonal earthen cross dams are made on the *Chharas* to provide irrigation water for *Boro* crops. Dams are generally set on the upstream so that water flow can be diverted into desired areas. These earthen dams are temporary, lasting from March to April. Most of the dams are washed away by the pressure of water during early monsoon. Bar *Chhara* and Bilas *Chhara* dams are established by the Mirzapur and Bhunabir Union Parishad respectively which give irrigation water to 300 and 500 ha of land. Table 9 shows water diversion of *Chharas* where this scenario is common.

Table 9: Seasonal agricultural dams and area coverage

| Name of *Chhara* | Crops served by irrigation | No. of Dam made along *Chhara* | Area coverage by dams (hac) |
|---|---|---|---|
| Kalni *Chhara* | Potato, *Boro* paddy | 1 | 2 |
| Bangua *Chhara* | Potato, Raddish, *Boro*, Tea garden | 3 | 60 |
| Pagla *Chhara* | *Boro*, Potato | 3 | 5 |
| Bar *Chhara* | *Boro*, Watermelon, Potato, Tea garden, Lemon | 3 | 300 |
| Boula *Chhara* | *Boro*, Potato, Watermelon | 5 | 250 |
| Bilas *Chhara* | *Boro* | 1 | 1000 |
| *Alia Chhara* | *Boro*, Potato, Wheat | 1 | 500 |

To control the water flows within the *Hail Haor* basin, submergible dikes were established in *Hail haor* basin by the Bangladesh Water Development Board (BWDB) in the 1960s. In order to ensure *Boro* rice irrigation during the dry season (November to March) and to protect *Boro* fields from the flash flood of early monsoon, submergible dikes were constructed. Local farmers suggest that these dikes are not serving useful purpose.

### 2.3.4 Sluice Gate

Two sluice gates were established by Agricultural Department of Sreemangal Upazila and *Satgaon* Tea Estate on the *Alia Chhara*. The lower one was established in 1997 at Badealisha village of Sreemangal *Upazila* and is still not operational. About 400 ha of *Boro* rice could be brought under cultivation during dry season if it is properly commissioned. The sluice gate in the upstream was established to control water during dry season. Two 8" dia. pipes were fixed in the sluice gate for downstream discharge but these are blocked with sediment particles. A diversion canal is used to discharge excess water. Recently a sluice was built in the middle reach (in between the metalled road and tea road) of *Boula chhara* watershed to enhance the irrigation facilities for dry season crops. It was reported by the farmers that about 400 ha of crop fields could be irrigated through many irrigation channels.

## 2.4 Sociological

The population in the Hail H*aor* watershed area is 2,71,038 in 51,163 households (Bangladesh Population census 1991, Vol.2). To analyze the socio-economic condition of *Hail haor* the area can be divided into 3 sub-regions. The upper part of the watershed which includes- tea estates, lemon & pineapple gardens and forest, the middle watershed (in between Tea garden road and metalled road for east and west sides of the *haor*) and the lower watershed (downstream from paved roads). Socio-economic conditions of the two lower sub-regions is similar in nature because of same culture, occupation and livelihood strategies of the people. In this respect MACH-CNRS socio-economic baseline data are used for socio-economic study of the inhabitants of the lower and middle sub-region. The socio-economic data of upper sub- region is also included to get the over all socio-economic condition of *Hail haor* watershed.

The socio-economic information was collected through direct interview, RRA, PRA and and acquired from GO and NGO Reports. In the report on the Baseline Survey and Monitoring Program of MACH-CNRS (February 2000), it is shown that 455 sample households were surveyed in the 2nd and 3rd sub- regions of the watershed.

Table 10: Households landholding size by classes

| Household Class | Holding Size (Decimals) | Households | | Landowned (Cultivated) | |
|---|---|---|---|---|---|
| | | No. | % | Area (Dec.) | % |
| Landless | 0-50 | 291 | 63.96 | 1436 | 3.98 |
| Marginal Farmer | 51-150 | 84 | 18.46 | 7772 | 21.55 |
| Small farmer | 151-250 | 42 | 9.23 | 8344 | 23.14 |
| Medium | 251-500 | 28 | 6.15 | 9905 | 27.47 |
| Large Farmer | 500+ | 10 | 2.20 | 8599 | 23.85 |
| All Classes | | 455 | (100) | 36055 | (100) |

Table 10 shows that 64% of the farmers are landless and dependent on labor selling, fishing, sharecropping. An estimated 64% landless farmers own 4% of the land while only 2.2% of large farmers owns 22% of land.

For upper sub-region, interviews and RRA were conducted to know the distribution of lands of *Balishira* and *Satgaon* hills. Household land holding size of the upper catchment is far different from that of the lower & middle subregion. In the upper catchment, there are above 20,647 ha of tea estates, 14,170 ha of lemon & pineapple garden and 2834 ha of reserve forest. Land holding size of farmers of *Faizabad* hills vary from 1.5-60 ha of which less than 3% of the farmers are categorized as medium farmer and 97% are large farmers. Most of the land of *Faizabad* hills is *khas* (government owned) except about 20% privately owned lands. Most of the lemon and pineapple gardens are occupied by the big business men from Sreemangal. They started farming during the 1970s, Farmers

applied to government (DC) for lease but it is yet to be decided. There are no settlement in the *Faizabad* hills for lemon and pineapple gardening. *Alia punji*, a *khasia* village is situated on the southern side of *Faizabad* hills occupying 160 ha of land. The ownership of the *punji* land is K*has* but leased out from government in 1974 and distributed among 125 families. The laborers of lemon & pineapple gardens of *Faizabad* hills come from the adjacent villages and tea garden labor line.

### 2.4.1 Indigenous community

*Khasia* and *Tripura* are the tribal groups of *Hail haor* watershed inhabitants.

Data has been collected from four *khasia punji* to understand the land use and agricultural practices. It is learnt that in K*hasia punji* (community), the Montri (Headman) of the community secure lease of *Khas* land from Government on behalf of the community and distributes land among the households of the community. Lands are distributed equally and under the same cropping practice resulting in similar economical status within respective *punji* households. Table 11 shows that landholding size of the farmers of *Alia*, *Laingla*sera and *Nahar* are mainly medium farmers while all the farmers of *Nirala* is large in category.

*Photo 2: Beetle Leaf cultivation (Pan Jum) in the Khasia punji Hills*

**Table 11: Landholding size of *Khasia* household**

| Name of *Punji* | Ownership | Area (hac) | No. of HHs | Landsize/HH (hac) | Cultivated crops |
|---|---|---|---|---|---|
| *Alia* | Lease & private | 243 | 125 | 1.9 | Beetle leaf, Beetle nut, Jack fruits, *Gol marich*, Lemon, Pineapple |
| *Nirala* | Applied for lease | 348 | 120 | 2.9 | Beetle leaf, Beetle nut, Jack fruits, *Gol marich* |
| *Laingla*sera | Applied for lease | 96 | 50 | 1.9 | Beetle leaf, Beetle nut, Jack fruits, *Gol marich* |
| *Nahar* | Nahar tea garden | 121 | 70 | 1.7 | Beetle leaf, Beetle nut, Jack fruits, *Gol marich* |
| Total | | 808 | 365 | 2.2 | |

*Tripura* tribe is another are indigenous group of people of this locality. Their number is however small. Before introduction of the tea business, *Tripura* was the only inhabitants of *Hail haor* watershed. They are now comparatively poor and land holding size is small. Findings of the workshop with *tripura* showed that the land holding size of households varies from 20-100 decimals among 90% of total households (i.e. landless to marginal farmers) and rest 10% households are small to Large in size. Household owns the land individually and generally grows lemon, pineapple and paddy.

## 2.5 Resource Uses

Land, water and climate of Sreemangal are optimum situationsfor most agricultural crop production. More than 120 years ago, *Hail haor* watershed area was covered with natural forest. Depending on the *haor* resources, the community adjacent to the *Hail haor* selected fishing as their profession. Presently 68 species of fish are found in *Hail haor* which meet the protein requirements of the population of surrounding areas.

It is reported that before 1850, most of the upper catchment was natural forest. During that period, only the indigenous *tripura* tribe was the inhabitants of this area. Indigenous people used to cultivate hill paddy and sugarcane and paddy by shifting cultivation process. Pineapple and lemon cultivation were started in the hills some 50 years and 30 years ago respectively. Presently lemon & pineapple plays the important role in the economy of Sreemangal.

### 2.5.1 Forestry

*Satgaon* and Lawachhara Reserve Forest (controlled by the State Forest Department) are located in the watershed of *Hail haor*. The natural forest vegetation of this area was converted to make plantation forest with valuable timber trees. Plantation in Lawachhara forest was started in 1920 and covers about 3470 ha of land of which 1243 ha are in the *Hail haor* watershed. About 1161 ha of land of *Satgaon* hills is converted to plantation forest by the Forest Department. Commercially valuable timber trees, Bamboo and Cane are common in the *Satgaon* forest.

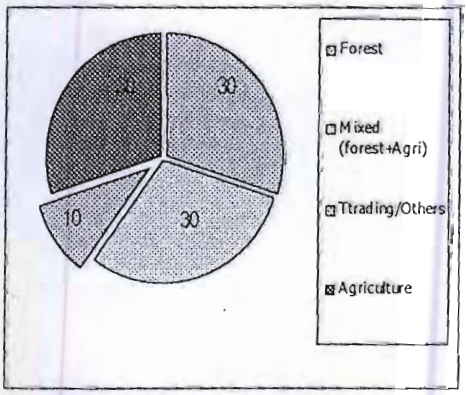



Figure 6: Occupational pattern

*Photo 3: Fire wood collection from forest*

The villagers adjacent to government forest harvest fuel wood, bamboo, and timber. A Rapid Rural Appraisal (RRA) evaluating the interaction between villagers and forest resources shows that 30% households are dependent on forest for their livelihood security while 30% villagers harvest forest resources for their domestic uses.

### 2.5.2 Hills & Valleys

*Hail haor* is surrounded by hills on three sides which are under cultivation depending on the water availability. The upper catchment of *Alia, Makria, Saria, Patria, Jaita, Laingla, Burbria, and Ful* are cultivated with lemon & pineapple. Table 11 shows that about 2361 ha of land is covered with lemon & pineapple gardens of which 60% are pineapple and 40% lemon.

Table 12: Distribution Lemon & Pineapple lands among the *Hail haor* watershed

| Name of Location | Name of Hill | Area under Lemon & Pineapple (ha) |
|---|---|---|
| *Faizabad* Hill | *Faizabad* | 529 |
| *Laiglasera* | *Balisera* | 442 |
| *Bishamoni-Mohazerabad* | *Balisera* | 1350 |
| *Jambura Chhara* | *Satgaon* | 40 |
| Total | | 2361 |

It is found from cost-benefit analysis that Tk. 2,85,000 to 7,50,000 can be made as profit from 1 ha of lemon garden (as reported by planters). It is also mentioned by the planters that Tk. 2,50,000 to 3,00,000 could be as profit from 1 ha of pineapple garden.

Land of Hail Haor watershed is being used intensively. The sub-watershed of *Jaita* and *Jaag* covers an area of 1164 and 1127 ha respectively. Among the *Jaita chhara* watershed, a portion is covered with Lemon-pineapple, Tea and settlement which are 265, 85 and 64 ha respectively. Aus and Aman are the major crop of *kharip1* (651 ha) and *Kharip 2* (648 ha) while 500 ha of land remains fallow during *Rabi* season. In the Jaag watershed 453 ha is under tea garden. During *Kharip1* and *kahrip 2* land is mostly covered with Aus and Aman (314 ha). A total of 257 ha of land remain fallow during *rabi* Season due to limited water.

The land use survey of *Jaag* and *Jaita chhara* has been conducted at *mouza* level. Map1 through 6 shows land use of *Jaag* and *Jaita* catchment area in different crop season.

*Photo 4: Lemon & Pineapple farming in the hills of watershed*

### 2.5.3 Tea Estates

Due to the altitude and high average precipitation, this zone is good for tea production. Around 20,633 ha, or 34 % of total watershed of *Hail haor* is covered with tea garden. Out of the total tea estates area 10,268 ha are under tea bush and the rest is Tea Estate's land under other uses. Of the remaining tea estate land, 449, 1305, 353 and 598 ha are covered with planted forest, natural forest, bamboo and sun grass respectively. Tea estate data shows that more than 70,000 people are dependent on the tea estates for food and livelihood security.

### 2.5.4 Plain Lands

The submergible low lands within the *haor* basin are mostly used for *Boro* rice. The wet land (deeper region) is habitat for a range of aquatic flora and faunal species.

Depending on the elevation, some land is suitable for *Boro* paddy cultivation during dry season whereas others are suitable for vegetables and paddy in all the cropping seasons of the year.

There are 21,600 ha of cultivable lands for paddy and vegetables. Different HYV and local varieties of *Aus, Aman* and *Boro* are grown in this area. In the high flat land of *Bhunabir* and *Mirzapur* Union, there are about 100 ha lemon garden. Due to scarcity of irrigation water during dry, season most of the high flat lands remain fallow.

### 2.5.5 Haor Resources

Table 13: Distribution of All Households

| Total | Fishing | | | |
|---|---|---|---|---|
| | Total | Full Time | Part Time | Subsistence |
| 6340 | 3081 (49%) | 1749 (56.77%) | 326 (10.58%) | 1006 (32.65%) |

*The Haor* is good habitat for fish, wildlife, birds and other flora & fauna. Table 13 shows that 6340 households (which is over 12% of total households living adjacent to *Haor*) are directly related with *haor* resources. Among them about 3081 households are dependent on fish for their food security to varying degrees.

Besides the fish resource, a significant number of house holds are collecting grass, reeds, aquatic flora & fauna as food, fodder and household materials. Wildlife and vegetation inventory reports that a total of 164 species of wildlife are found from Amphibian, Reptilian and Avifaunal and mammalian classes in different seasons. Vegetation surveys reveal 84 species of aquatic plants.

## 3. PROBLEM ANALYSIS

The watershed management approach for hail *haor* is participatory. Users of natural resources of the *haor* are directly related to the resources and thus they are often aware of degradation as well as how to recover from the degraded state. The project emphasizes the involvement of the community from the very beginning of the project planning to impact monitoring. Participatory community planning exercises have been done with different stakeholders of the watershed. Table 13 shows that a total of 5 participatory community planning programs have been conducted at different locations of Hail Haor watershed with different stakeholder groups.

**Table 14: Groups, Locations, and number of Participants of the workshop**

| Groups | Locations | Number of participants |
|---|---|---|
| *Tripura* Farmer | Bishamoni | 24 |
| Paddy Farmers | Ashidrone | 43 |
| Lemon & Pine apple farmer | *Alia Punji* | 36 |
| Flat Land's Lemon Farmers | Bhunbir Union | 50 |
| Tea estate resource planners | PDU, Bangladesh Tea Board | 17 |

In addition to the participatory planning workshops, the existing situation of *Hail haor* watershed has also been explored physically. To identify the problems of watershed, various scientific techniques have been applied blending with community participatory approaches. The water sources, vegetation cover, forest, aquatic habitats have degraded due to human interactions, and natural causes. Problems related to the watershed of *Hail haor* are identified in the problem census workshops. From the output of community participatory workshop regarding problem & solution analysis, it has been found that scarcity of irrigation water during dry season, improper land use of slopping terrain and excessive siltation, *Chhara* bank erosion, use of agro-chemicals in the upper catchment are the major problems of the *Hail haor* watershed.

A total of of 22 *Chharas* were selected, considering water carrying status of *Chhara*, to study water discharge and sediment load. The water flow velocity, water level, volume of waterdischarge have been measured at weekly interval. Chhara sediment and water discharge monitoring started from November '99 to October '00. To measure sediment rate, water samples (1 litre volume in each sample) are collected during measurement of water discharge. Sediment rate is measured during May to August as erosion and subsequent silt load is higher during this period and insignificant during other part of the year. Sediment load of *Alia* and *Jaita chhara* from *Satgaon* hill was 941 and 817 tons respectively during June, the highest rainfall month of the year 2000. Sediment load by the *Bilas chhara* was 540 tons during the month of June, 2000. These huge sediment load from the *chharas* is raising the *haor* basin bed at an alarming rate.

Community insight is important to understand the part of the problems. Problem census and analysis were done in the PCP workshops. The participants presented solution to their respective problems. The major problems according to the findings of workshops are: soil erosion and top soils loss, lack of knowledge for managing orchards, siltation in haor basin, scarcity of water during dry season, insect infestation, use of agro-chemicals in the upper watershed.

The workshops were held at different locations of the watershed based on the inhabitant's occupation, farming practices, and the community locations. Lower watershed lemon and pineapple gardeners, paddy farmers, *Khasia* and *Tripura* community, tea estate manager, school teachers and local elite

were the participants of the respective workshops. Land holdings were also considered for selecting the participants.

### Village workshop

*A brief methodological overview:* The method incorporates three distinct steps, problem identification step, a cause and effects of the problem and a discussion on solutions. The workshops were inaugurated mostly by the Chairman of Union Parishad or chief or important respected person of community. The main focus of the plenary session is to identify problems related with the watershed and to list out problems followed by problem prioritization. All documentation were done in the Flip Chart.

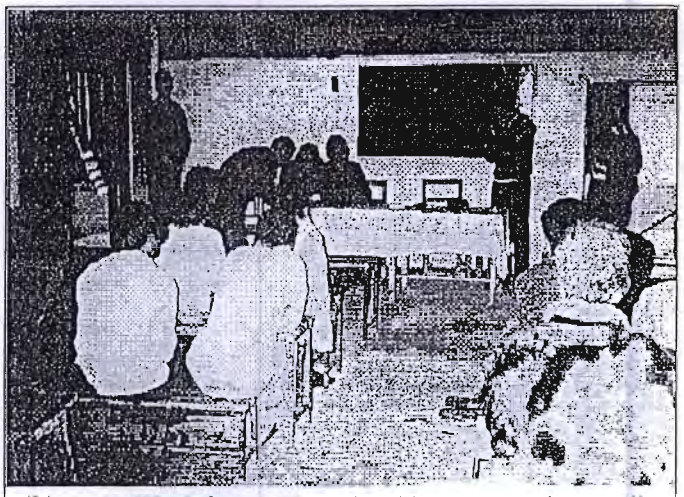


*Photo 5: Workshop with hill cultivators at Alia Punji*

In the 2nd session of the workshop, the causes, effects and solutions of sorted out problems were discussed and finally written down. In the 3rd session, the problems, causes and effects were reviewed and impacts of interventions to achieve the solutions, on different stakeholders, were discussed. Appropriate time for the intervention, technical feasibility, environmental feasibility were also considered regarding intervention implementation.

## 3.1 Problem Census and Planning Workshop

The matrix of problem census and planning for interventions were conducted separately for beetle leaf, lemon and pineapple growers, and also for stream and soil restoration aspects. An interactive discussion and sharing of ideas resulted in the identification of a set of existing problems and recommendations for interventions.

The workshops have been conducted at *Bhunabir*, *Ashidrone*, *Bishamoni*, and *Alia punji* by the Project Development Unit and Bangladesh Tea Board, Sreemangal center among the different stakeholders group. The findings of the workshops are shown in summarized form in Table 14:

**Table 14: Findings from Participatory Workshop**

| Problem | Solution |
|---|---|
| | Beetle Leaf |
| • Land fertility decreased | • Hold topsoil in place by inserting tree stem as pillar around the beetle plant and placing leaves and small branches within the pillar frame.<br>• Create natural protection through green coverage around the orchard and along the bank of the streams |
| • Land slide | • Contour bunds at the hill foot with tree stems, leaves and branches. |

| Problem | Solution |
|---|---|
| | • During rainy season if needed trim the under coverage of vegetation, just around the plant stem base not every where<br>• Plant trees I all conspicuous places.<br>• Create vegetation coverage with *Rema*, *vetiver* grass, boudelia along the edge of the hill |
| • Disease *Utral/Dausha* Stem base rotting | • Need training and technology to combat disease |
| **Pineapple** | |
| • Soil erosion | • Contour bunding at hill foot<br>• Contour plantation<br>• Trimming weeds, not de-weeding |
| • Scarcity of quality saplings | • Provide training<br>• Supply quality sapling |
| • Lack of knowledge and skill for proper management of the orchard | • Provide training |
| • Less productivity | • Contour planting in such a way that makes the pineapple plant stable as rows on the ground |
| • Soil degradation and poor profit | • Shifting from pineapple to other crop like lemon |
| **Lemon** | |
| • Pest infestation and disease | • Provide training and adopt control measures |
| • Transportation problem | • Build paved road |
| • High cost to develop a lemon orchard | • Provide soft credit facilities |
| • Soil erosion | • Trim weeds<br>• Contour bunding at hill foot<br>• Credit for contour bunding |
| • Scarcity of water during dry season | • Plant trees in the upper catchment<br>• Create riparian green coverage with grass<br>• Enhance water flow in the smaller streams connecting them with the perennial stream.<br>• Build sluice gate in the Joita, Boula and Bara Chhara<br>• Dig ponds in the area to store water for dry season use<br>• Sink power driven tube wells to pull underground water<br>• Provide soft credit for pond digging and tube well sinking<br>• Afforest degraded and denuded hills |
| • Lack of knowledge and modern technology for lemon orchard management | • Provide training and motivate undertaking of proper land use |
| **Stream** | |

| Problem | Solution |
|---|---|
| • Scarcity of water during dry season | • Increase vegetative cover in the hills for enhanced percolation of rain water and increasing dry season flow<br>• Establish sluice gates for proper distribution of water in the following areas;<br>• Provide irrigation from different *Chharas* by creating irrigation drains<br>• Create riparian green coverage with grass<br>• Enhance water flow in the smaller streams connecting them with the *Joita, Alia, Joita, Boula and Bar Chhara*<br>• Dig ponds in the area to store water for dry season use<br>• Establish power driven tube wells to pull under ground water<br>• Provide credit for pond digging and tube wells<br>• Afforest degraded and denuded hills<br>• Set a deep tube wells |
| • Water pollution | • Hold deliberations with relevant ministry, tea board and tea estates |
| • Stream bank erosion | • Decrease steepness of stream banks where necessary and feasible<br>• Create riparian vegetation with bamboo, *vetiver* grasses and other fibrous rooted herbs and shrubs<br>• Plant trees like- domestic bamboos, *Jarul, Arjun, Kadam, Semul, Rangi, Rata, Bandarhola, Kainjal* in the riparian area<br>• Put riprap/bamboo clump at the meander of *chhara* for bank stabilization<br>• Dig *Chhara* and stabilize *chhara* bank with strengthened embank**ment,** and establish riparian vegetation with *Borak* and *Jai* bamboo, *Kewa kanta, vetivar grass* and *Bakhal.* |
| • Barrier for draining out up stream water | • Make the railway and other road bridges more wide to swiftly drain out rain water |

## 3.2 Orchard Practices Review Meetings

Workshops on Management of *Hail haor* watershed so far as it relates to tea estate and orchard cultivation wwre organized and participated by expert tea planters and officials of the Bangladesh Tea Board, Sreemangal. In the workshop, potential techniques for erosion control and recovery of the ecological balance of watershed were focused and deliberated by the participants. These special cultivation communities have suggested various site-specific detail activity plans for implementation. The project plays its role as facilitator to the community. Possible project interventions were assessed for feasibility through participatory planning workshops with the various resource users groups.

A total of 5 meetings were held at Faizabad hill area, Lainglachhara, Mohazirabad, Mirzapur and Alia punji with lemon and pineapple planters. The meeting was facilitated by expatrate orchard expert Roy Batty. A final workshop facilitated by the said orchard expert, based on the result of the 5 five earlier discussion meetings, was held in the MACH Sreemangal Site Office to deliver the proper orchard management system to the planters (Annex-5a & 5b). The *Upazila* Agricultural Officer, Representative from Farmer to Farmer Program (FTF) of India and MACH-CNRS staff

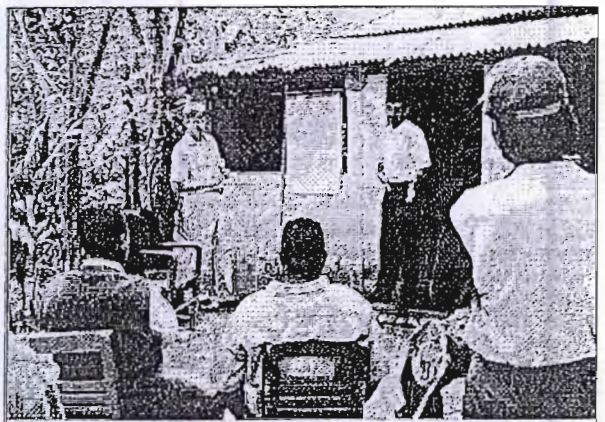


*Photo 6: Meeting with the Lemon-Pineapple planters*

attended the workshop. Technical papers on orchard management were provided to the planters.

In order to identify specific problems related to lemon and pineapple orchard management, 5 discussions meetings have been conducted with the orchard managers in the watershed. In every discussion meeting, 10-15 orchard managers participated. Discussions were held on the orchards and it was open for all planters to participate and deliberate. In these discussion meetings, orchard farmers pointed out the problems and the orchard expert investigated the points raised, analyzed problems with the participants, and attempted to find out causes, effects and solutions to the problems raised. Later on a comprehensive guideline/manual has been prepared to address the problem. In a final workshop on orchard management, the out come was presented and discussed.

## 4.0 SEDIMENT LOAD

Erosion in the upper catchment due to the deforestation, unwise agricultural practice, lack of scientific management and natural calamities are the causes of subsequent sediment deposition in the lower basin of watershed. Erosion and siltation are interrelated problems. In the *Hail Haor* watershed, eroded soil particles of hills and *chhara* bank are transported by the stream flows. The soil erosion and consequently silt load in water discharge varies depending on the vegetation coverage, agriculture practice and cropping pattern in the sub-watershed. Rain brings the eroded soil along with water. Sreemangal is the highest rainfall area of Bangladesh. The annual rainfall varies from 2500 to 4000 mm, May-July being the highest rainfall months. Erosion is proportionately related to rainfall intensity and caused due to degradation of vegetation of the upper catchment.

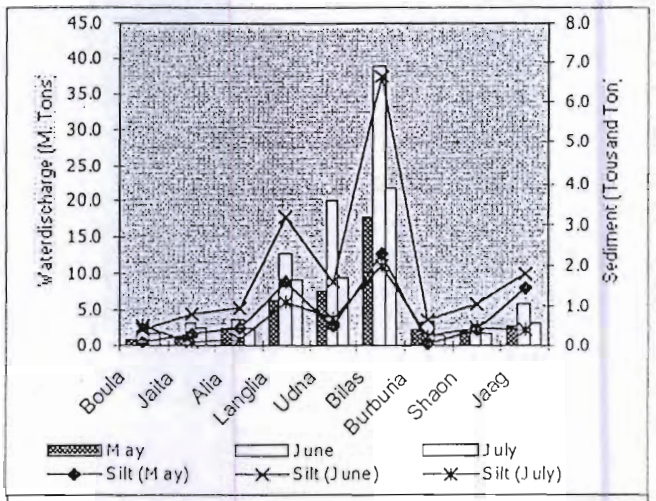



Figure 7: Comparative water discharge and sediment loading of different Chara

Figure 7 shows that sediment load is increasing with increasing water discharge of *chhara*. Bilas, Laingla and Jaag chhara carry comparatively high sediment than the others. The sediment load also depend on the nature of land use in the catchment area of *chhara*. For example, *Udna chhara* sediment load is comparatively low whereas provides 2nd highest amount of water flow among all the *chhara*s. The reason for low sediment load is undisturbed upper catchment and good vegetation coverage. Kalenga chhara, a tributary of Udna, drains water from Kalenga Reserve Forest where the soil is less disturbed. There are other tributaries of *Udna chhara* draining from rubber garden and tea garden.

## 5.0 LAND AND WATER USE

### 5.1 Land Uses

Extensive as well as unwise use of hills is a crucial problem for *Hail Haor* watershed as water with eroded soil load drains to the haor. Tea gardens, pineapple, lemon, paddy, forest and settlements are the organized use of the lands. In the hilly areas, hill cutting, conversion of hilly topography is a major problem for degradation of hill habitat and ecosystem and consequently change of bio-diversity. Degradation and in extreme cases, denudation of vegetation are the primary causes for land slide and soil erosion.

Within the upper catchment of the *Hail haor* watershed, 4% land area is under lemon and pineapple cultivation. Pineapple cultivation with 'across the contour' or vertically up and down line planting layout, and spading of steep hill slope for soil preparation for pineapple cultivation are causing severe erosion and land slide.

High flat land and floodplains are used for paddy and vegetable cultivation. Among the *Rabi* crops *Boro*, potato, watermelon etc. are mostly grown, Due to scarcity of irrigation water during the dry season, most of the high flat lands remain fallow. Cultivation in the watershed is directly related to water diversion facilities from the *Chhara*.

To understand the land use pattern at sub-watershed scale, land use surveys for *Jaag* and *Jaita chhara* sub-watershed have been conducted using *Mouza* maps at plot label during the last year (Annex-13). Cropping season survey has also been conducted to get the data for entire year. Table- 15 shows that there are 268 ha of lemon & pineapple in the *Jaita chhara* sub-watershed which is a terrible factor for soil erosion. Tea garden occupies tangible volume of area in the both sub-watershed. There are huge fallow lands in both *Jaita* and *Jaag* sub-watershed due lack of irrigation facilities and natural *Udna chhara* inundation.

Table 16: Land use type of Jaita and Jaag sub-watershed in different cropping season

| Land uses pattern | Jaita Sub-watershed | | | Jaag Sub-watershed | | |
|---|---|---|---|---|---|---|
| | Rabi (Ha) | Kharif-1(Ha) | Kharif-2 (Ha) | Rabi (Ha) | Kharif-1 (Ha) | Kharif-2 (Ha) |
| *Aus* or *Boro* | 56.4 | 716.9 | 717.7 | 318.6 | 0.4 | 183.2 |
| *Aman* | 0 | 0.1 | 0 | 0 | 318.2 | 0 |
| Wheat | 0.7 | 0 | 0 | 0 | 0 | 0 |
| Lemon/Pineapple | 268.0 | 268.0 | 268.0 | 0 | 0 | 0 |
| Beetle Leaf | 0.2 | 0 | 0 | 0 | 0 | 0 |
| Vegetables | 99.0 | 0.2 | 0.2 | 2.7 | 2.5 | 3.5 |
| Sun Grass | 13.0 | 13.0 | 13.0 | 1.4 | 1.4 | 1.4 |
| Tea Garden | 142.6 | 142.6 | 142.6 | 458.6 | 458.6 | 458.6 |
| Social Forest | 4.2 | 4.0 | 4.0 | 41.1 | 41.1 | 41.1 |
| Khal/ Pond | 24.8 | 24.6 | 24.6 | 38.2 | 38.2 | 38.2 |
| Settlement | 64.5 | 64.5 | 64.5 | 62.7 | 62.7 | 62.7 |
| Fallow land | 562.2 | 1.7 | 1.0 | 125.6 | 125.8 | 260.2 |
| *Total* | *1235.6* | *1235.6* | *1235.6* | *1048.9* | *1048.9* | *1048.9* |

## 5.2 Water Use

High diversity of both animals and plants is associated with water courses. Rational distribution of water for the different habitats and organisms is crucial. The local community reported that previously *Chharas* were the ways for distributing water into different parts of watershed but now it is not active due to degradation of watershed vegetation and also diversion of water at upper catchment of *Chharas* by man.

Tea, pineapple & lemon garden's unwise land management have been accelerating the rate of runoff. In the year 2000, early rainfall caused flood in the lower basin of watershed that caused damage to crops.

Water users in the watershed could be classified according to their agricultural practice. The tea estates are by far the large land users in this tract. Tea planters store water by damming and pump out water (both from surface reservoirs and ground water). The lemon farmers are financially well off and employ pump to use water from the *chhara*. As there is lack of appreciation and awareness, and also

scarcity of water, users of upper reaches do not consider the need for the down stream users and not at all for the wetland situations. Upper catchment water users misuse water and increase erosion by over use of water.

The downstream water users complained that they do not get adequate water for cultivation as water is diverted by the upstream people excessively by creating reserviirs through construction of earthen cross dams in the *Chhara*. These cross dams store considerable amount of runoff. Submergible cross dams are also established at different points of a *Chhara* to raise water level. Downstream people do not get adequate water unless the *Chhara* has significant water flow. Out of 59 *Chharas* inventoried, only 13 *Chharas* have enough flow to submerge the earth dam and allow overflow of water for down stream users.
There is no dry season water flow in 20 *chharas* out of a total of 59 chharas of *Hail Haor* watershed although, in the distant past, they had dry season water flow. Water-discharge data reveals that dry season water discharge is decreased considerably because of the upstream dams. *Kaila, Burchungi, Patria, Khai, Shial, Kakia,* and *Phool chhara* are draining comparatively low quantity of water from February onwards in the dry season.

## 5.3 Habitat Degradation

Formation of habitat is a functionality of the land and water interactions over the landscape. Habitat thus created supports life forms. The natural harmony establishes certain floral and faunal niches to support plant and animal species. The interaction between the land and water governs the ecosystem and biological production. Human population is an integral part of the ecosystem and influential member of the food chain and food web. Due to increased need and greed, lack of proper understanding and for personal agenda, human beings intervene in to the system. Along with the natural causes, the human interactions bring changes in the system. For example, deforestation in the watershed accelerates topsoil erosion of the hills and valleys and at the same time silt up the *haor* basin degrading the wetland habitat. Deforestation of riparian vegetation increases bank erosion, reduces dry season water flow, and silt up the stream bed. The silted up stream beds reduce the water carrying capacity as a whole. Deforestation reduces ground water percolation and subsequent discharge, and increases runoff. Over harvesting of natural resource without proper management lead to a collapse of the system. Deforestation and riparian vegetation destruction lead to the reduction of bio-diversity. For wildlife, the situation is worse as there is little or no habitat left for them. There are some segregated patches of wildlife habitat but a few wildlife corridors for their movement.

It was gathered from various meetings and workshops that some 10-12 decades back, hills, *Chhara* banks, *haor* wetlands etc. were covered with natural forest, riparian and aquatic vegetation. *Hail haor* watershed was a good habitat rich in biodiversity. To increase cropping lands and to eliminate ferocious wild animals from the area and money making by influential people, these forests were cleared. Changing of natural forest to plantation forests has also occurred in the area that shows low level understanding of the concerned people about the importance of the ecosystem.
It is also observed that habitats become segregated due to loss of connectivity among the habitats. Connectivity is necessary for facilitating movement of fish and wildlife from one habitat to another. Due to degradation of riparian vegetation along *Chhara* bank, wildlife especially terrestrial animals and shy birds, cannot move from forest of upper catchment to lower basin and *vice versa*.

### *5.3.1 Deforestation*

A significant forest area coverage (around 25%) is required for a country for its ecological balance and environment equilibrium. All climatic parameters such as precipitation, temperature, relative humidity etc are directly related with forest or vegetation coverage. A huge forest area of *Hail haor* watershed was converted to tea, lemon, pineapple gardens and settlements. Among the *Hail haor* watershed, 39% of land area is covered with tea garden that was created by clearing deep natural forests some 130-150 years back. Though the tea plant provides vegetative cover but these uniform

height plant mass is not as good as multi-storied forest vegetation to intercept rainfall. Furthermore, the ground cover and shrubs are removed from tea plantations to ensure more fertility for tea plants so that the run off is higher under tea. Due to a higher run-off, the water table is not maintained at previous levels. Higher run-off in the upper catchment causes soil erosion and at times land slides in the rainy season, while lower water table in the dry period. The eroded soil is transported through the *Chhara* and some are deposited in the chhara bed while the rest carried to *Haor* silt up the basin leading to major degradation of aquatic habitats.

Lemon and pineapple gardens cover 2360 ha. of land in the watershed which was previously under natural tropical forest. The indigenous *Tipra* community used small area of hills and hillocks for shifting cultivation on a long fallow cycle and the rest was undisturbed forest. Pineapple cultivation came up in the area during 1950s and lemon during early 1970s where upon the balance hills and hillocks were cleared. This exposure of the tropical forest floor and its conversion to intensively managed orchards degraded the habitat severely and affected the biological life systems in the tract as well as the communities living in and around. The practice of steep hill slope agriculture is one of the main causes of wet land degradation by silting up *chhara* bed and *haor* basin.

The forest villagers of *Lawachhara* Forest Beat reported that this habitat contained large mammals even prior to 1950's. But migrated people from different parts of Bangladesh as well as immigrants from *Tripura* and other States of India cleared the forest that drove away the animals from this tract. Timber stealing is now a serious problem not only for the forest administration but also for the tea estates as reported by the forest officials and tea estate management. The shade trees of tea gardens and bamboo, timber trees of State Forests are cut down on a regular basis which is contributing to deforestation process.
It was reported in the participatory workshop that shrubs growing on *Chhara* bank, connecting creeks, hills and valleys like- *Dhol kalmi, futki, pisach kata* etc are regularly cleared by the adjacent land owners to expand area of cultivable lands as well as to damage the dwells of snakes, jackal, rats and other wild lives. Such land clearance cause instability of the *chhara* bank including sheet and gully erosion.

In the workshop with paddy farmers, participants reported that the coarse sand coming from the *Udna* and *Bilash Chhara* is deposited on the crop fields of *Bhojepur, Udnarpar, Ashidrone* villages of *Sreemongol Upazila* and these make the farm land infertile. Such soil erosion is the direct cause of hill cutting for converting sloping lands to agricultural uses and deforestation activities in the up stream catchment areas.

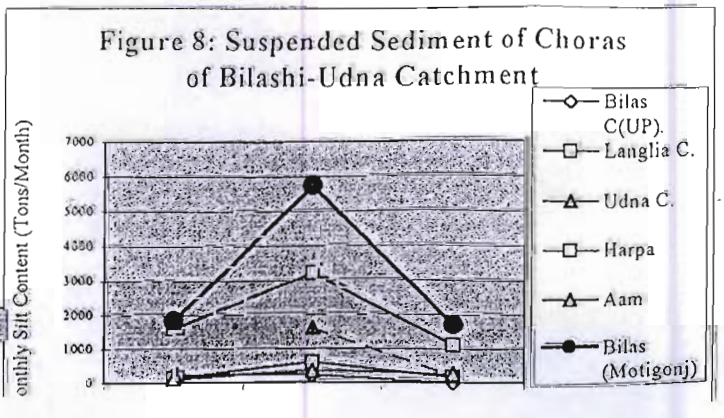
### 5.3.2 Hill Habitat Conversion

Conversion of hilly terrain for cultivation and improper management of orchards on the slopes continues to be the major causes for soil erosion, land slides, and changes of soil quality. Eroded soil from upstream is raising the *haor* bed and is responsible for the degradation of aquatic bio-habitats. Conversion of delicate hilly habitat for intensive orchard and other forms of agricultural uses must stop.

### 5.3.3 Siltation

*Hail haor* receives a large amount of sediment from all the *Chharas* draining to it. Intensive cultivation, upstream deforestation, steep slope agriculture, hill cutting for conversion of lands to agricultural uses are responsible for higher erosion as well as land slides. Eroded soils through runoff and stream

Figure 8: Suspended Sediment of Choras of Bilashi-Udna Catchment



flow deposits on the floodplain, stream beds, *Beels and haor* basin. According to the studies conducted, the hail *haor* bed is rising 20 cm every year (MACH). Increasing siltation proportionally decreasing habitats for aquatic organisms especially for fish and ultimately hampering income of fishers as well as protein supply and consumption of subsistence people.

### 5.3.4 Bio-diversity

Bio-diversity of *Hail haor* watershed is declining due to the degradation of habitat. Deforestation, habitat degradation, conversion of habitat to other uses, unwise resource harvesting and lack of proper management of watershed, riparian zone and *Haor* proper are causes for declining fish, wild life, birds and other aquatic flora and fauna.

Lack of proper management of natural resource is one of the main problem for maintaining bio-diversity. As mentioned earlier, indiscriminate clearing of forests and vegetation reduced plant species and wild lives. Irrational harvesting of common resources and cruel behavior to wildlife are the other reasons for reduction of bio-diversity. Aquatic species have been reduced due to loss of habitat, degradation of habitat and lack of proper management. For example, the water bodies of *Hail haor* are let out under leasing system and the lessee harvests fishes by de-watering the water bodies, even though the same is prohibited by law. Complete de-watering of the deepest pockets of the wetlands eliminates brood stock altogether and limits & ultimately eliminates recruitment thus reducing bio-diversity. Loss of connectivity due to embankment/dams also stops recruitment in to the wet land from external sources. The fish or other aquatic species that need more than one year to mature for reproduction are almost absent in the wetland. The situation must improve in the interest of biodiversity conservation and resource building for future use.

Aquatic birds of *Hail Haor* have decreased drastically in the last 8-10 years. Hunting, "Night light fishing", degradation of aquatic habitat are the major causes of birds declining. FAP 6 report mentioned that "The main reasons for the disappearance of so many wetland bird species from the north-east region are undoubtedly the massive compression of floodplain grass lands and seasonal swamps to agriculture land, and almost complete elimination of swamp forest and other native floodplain forests which provided secure roosting and nesting sites for large water birds. Direct persecution by man has doubtless played a significant role in the demise of some species, but loss of permanent wetland habitat seems to be of less importance. Indeed, much of this habitat still remains"(FAP-6, Page 65). Restoration of the habitat could only stage a come back of the lost heritage and thus call for appropriate intervention under the project.

### 5.3.5 Ecological Connectivity & Infrastructure

Every individual life system of nature has its own cycle of maintaining livelihood and propagation. Individuals need safe home for themselves as well as for their offspring. The habitat, niche and territory are of crucial importance for the sustainable survival of the wildlife. Ecological connectivity is very much essential for wildlife food security, safe dwellings and continued regeneration. Massive destruction of forest for very many reasons resulted in shrinkage of habitat and often caused ecological discontinuity leaving segregated, isolated patches of wildlife habitat. Stream bank vegetation (riparian vegetation) of sufficient depth serves as wildlife corridor but these have been cleared. Reestablishment of such riparian corridor is in indispensable requirement for multiplication and continuity of species, and must be catered for under the project program.

Infrastructure development came along as an integral part of the development in the watershed as in the other parts of the country. Making infrastructures like railways, roads, dams, settlements and destruction of riparian vegetation are the prime causes of losing ecological connectivity which should be restored.

Connectivity of the water bodies is essential for many aquatic species as they pass different phases of their life cycle in different habitats and connectivity allows them to move, migrate and drift to the desired and secured habitat.

It was uniformly reported by *Haor* users and *Haor* neighbors that fish and other aquatic species and their abundance in *Hail haor* is decreasing as connectivity of different water bodies with river has almost been lost (*Kamar Khali* sluice gate and embankment discontinued the connectivity of this *Haor* with the *Kushiara* river). At the same time, siltation of the water bodies like streams flowing from the watershed resulted in loss of connectivity.

Stream corridor discontinuities in the *Hail haor* watershed, by constructing dams, embankments and sluice gates to control water flow, is common which isolated the habitats of upper catchment from lower catchment. For instance, aquatic life's movement is hampered by establishing the cross dams and sluice gates in the upstream of *Chhara*. The natural system needs to be understood and connectivity reestablished to create congenial habitat for fish multiplication, fish diversity, critical season shelter and the ultimate sustainability.

## 6.0 PRIORITY ANALYSIS

Several workshops were conducted with different stakeholders at different locations to identify the problems related to watershed of *Hail Haor* and fixation of priorities for addressing these problems. The goals and objectives of workshops were to identify problems and their probable solution prioritizing the implementation schedule. Indigenous knowledge of user community and scientific restoration plans and recommendations for sustainable management of watershed resources were also considered during the fact finding process.
To restore the watershed of *Hail haor*, interventions would be of both Macro and Micro levels.

## 6.1 Macro Interventions

For the restoration of watershed ecology of *Hail haor*, pressure on watershed resources and improper land use practices should be reduced. Reintroduction of the ecological entities that were present before indiscriminate exploitation began would need to be considered simultaneously with restoration programs. To improve the entire watershed in an organized way, restoration program should be initiated by the GOB policy makers with direct participation of the community . It revealed from the findings of participatory workshop that plantation along *Chhara* (regeneration of riparian vegetation), ban on cultivation on hill slope, extensive afforestation, of delicate hill slopes, stopping conversion of hilly land for agricultural uses, proper sharing and reduction of misuse of water would be the prime measures to recover degraded watershed. Awareness campaign on natural resources management would have to be organized to build up consciousness and consensus for a sustainable management of the watershed.

### *6.1.1 Regeneration of Riparian Vegetation*

The riparian vegetation is degraded due mainly to exploitation of trees as fire woods, timber and forage, and extension of agricultural cultivation and gardening. Vegetation coverage along the stream are required to be developed to stabilize the bank of the *Chhara*. Three-storied canopy of tall trees, medium trees, and shrubs with ground vegetation would be established to decrease rain drop erosion, increase water percolation in the sub-soil and improve soil holding capacity of the hill slope and *chhara* bank.

Field reconnaissance revealed that presently 59 *Chharas*, big and small, transport total water from the watershed to *Hail haor*. The total length of these *Chharas* is about 360 km of which 95% of the water course is degraded in different ways. To reestablish riparian vegetation along streams of the watershed area, a total length of about 175 km *Chhara* would need replanting with trees, shrubs and grass cover.

Community participation to reestablish riparian vegetation along these *chhara* banks to enlist their support and cooperation for initial program implementation and future sustainability of the resource generated .

### 6.1.2 Desilting Connectivity

*Hail haor* flood plain is economically important both for fishers and paddy farmers. To improve the over all status of flood plain, connectivity among *Beels*, *Chharas* and Rivers has to be reestablished. Water congestion in the *Hail haor* basin during late monsoon delays the plantation of *Boro* rice. Unseasoned sowing of rice hampers expected production and output. De-siltation of canal, *Beel* and river would drain out excess water from the flood plain as well as reduce scarcity of water during dry season.

Restoration of connectivity would enhance fish movement, which ultimately increase fish diversity and abundance. In the workshop held at different parts of *Hail haor*, the local community reported that *Jethua, Sanandar*, and many other connecting natural canals should be rehabilitated to reestablish connection with different categories of water bodies for improving drainage and fish movement.

### 6.1.3 Re-excavation of Water Bodies

131 *Beels* of varying size could be recognized in the *Hail haor* watershed ( *Beels* are the deepest water bodies of the *haor*). Sediment coming from upper catchment of watershed silt up the depressions raising beds of water bodies. Although most of the *beels* retain water during peak dry season but the level of water is not adequate for secured fish living. To enhance security and quality of aquatic living beings, silted up *Beels* should be re-excavated and maintained regularly. Based on the participatory workshops findings, Jethua *Beels* and canals were re-excavated in the last dry season (March, 2000). User community urged for re-excavation of *Sanandar Beel, Chiruadubi Beel, Bakkia Beel* to enhance production and security of fish and other aquatic flora and fauna.

### 6.1.4 Maintain Proper Cultivation Techniques for Hilly Area

Deforestation, exposure of hilly terrain and cultivation of step hill slopes by disturbing soil are the principal causes for soil erosion, land slide and silt deposition on the stream and river beds, and basin bottom of *Haor*. Cultivation on the hill slopes would be banned, regulated or limited to easy gradients with protective regulatory measures to reduce soil erosion, landslide and to improve soil quality, and also to encourage regeneration of natural forest vegetation. For limiting cultivation on hills and steep slopes, rules and regulations for cropping pattern, design layout and management system would be supplied to the gardeners, and GOB would be urged to activate its control and regulatory authority to ensure better land use of the watershed.

According to Roy Batty, a Volunteer from Farmer to Farmer Program, cultivation on slope having more than 45% gradient is not permissible and thus should not allowed in the interest of guarding against soil erosion and nutrient loss. He profusely encouraged the lemon and pineapple planters to avoid cultivation on steep slope area. As to cultural operation in the orchards and tea gardens, herbicides (*Glyphosate*) should be applied to kill weeds rather than spading out weeds by soil working and thereby disturbing slope soil. Contour planting method of pineapple cultivation instead of the current 'across the contour' planting practices should be adopted.

## 6.2 Micro Interventions

### 6.2.1 Regeneration of Riparian Vegetation

The *Chhara* banks are rich in soil fertility, nutrient contents and moisture regime affording better growth for plant communities. To ensure secure habitat for wild life, restoration of riparian vegetation is essential which will also provide safe corridor for wildlife movement to different habitats. Currently *chhara* banks are continuously eroded primarily due to absence of riparian vegetative cover and also land clearance for cultivation right up to the *Chhara* bank point. It has been observed that at present tree, shrubs, herbaceous cover and shoreline emergent vegetation cover on the riparian zone is 27, 19, 59 and 52% respectively (average for both sides of *Chhara*). Cent percent coverage of three-storied canopy i.e., tall tree, medium tree and ground vegetation is required to stabilize *chhara* banks which should be restored. As far as practicable, indigenous varieties of tree, shrub and herb cover should be ensured by collection of local provenance to maintain continuation of indigenous habitat.

Riparian vegetation along *Joita* (middle & lower reach), *Jaag* (lower reach), *Alia* and *Boula chhara* would be reestablished through plantation, and the move in this direction is already on. Plantation works have been undertaken after formation of Resource Management Organization (RMO). RMOs in collaboration with the project personnel planted trees and shrubs on riparian zones. Vetiver hedge would be established for bank stabilization and such work have to be undertaken during pre-monsoon dry season. Implementation of these programs are demonstrations to the community for future restoration works.

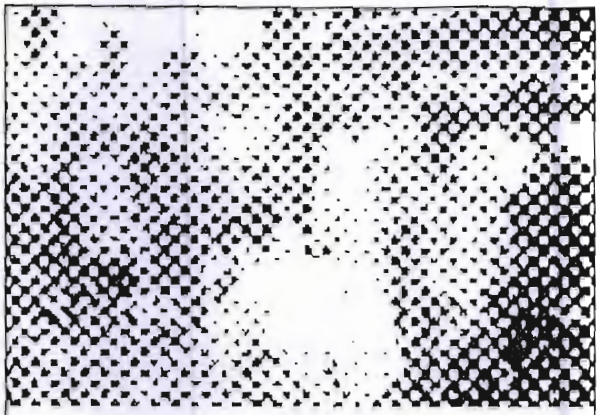


*Photo 7: Plantation to enhance riparian zone*

Over 15,000 tall seedling of different local and exotic varieties viz. *Chapalish, Arjun, Gamar, chikrassi,* Koroi, Jack fruit, *Sissoo, Mahogony, Minjiri,* Akashmoni, Mangium,etc. have been planted along the *Jaita, Alia, Boula and Jaag Chhara.* Five RMOs, including the landowners adjacent to *chharas* and representatives from different Union Porishads were formed to restore the riparian zone vegetation and their sustainability.

### 6.2.2 Erosion Proofing Measures (Vetiver grass & Plantation)

Soil erosion and land slides are a major problem of hilly area. Lemon and pineapple cultivation at *Satgaon* and *Balishira* hills cause erosion and silt transportation with water, and subsequently these silt raise the bed level of the streams and *Hail haor* basin. In order to reduce soil erosion, several measures would be undertaken. Afforestation in the watershed, less erosive agriculture practice and cropping pattern would be demonstrated and promoted. Contour bunding would be done to reduce the flow of silt to the streams. Local people opined that earthen or bamboo bunding would in course of time be washed out by the run-off. So deep rooted grass like vetiver would be planted along contour to hold soil from being carried by run-off and also to reduce the pace of run-off. Deforestation, conversion of land for agricultural use and intensive cultivation in steep slopes of hills has to be stopped to restore watershed quality. Creating vetiver hedge on the contour of hills and slopes before starting cultivation would be an appropriate technique to reduce pace of run-off as well as erosion.

Afforestation would be done choosing deep rooted tree species for plantation on the hilly area to reduce the threat of land sliding. Awareness campaign conveying the message of the adverse affects of soil erosion and economical benefit of trees would be demonstrated to users for encouraging afforestation individually.

Tree seedling supply to the community, especially to the poorer section of the people free of cost, for planting on the slope and around homesteads, could be a motivating program. The community would be directly involved in the program primarily to make it a broad-based and total program, sustainable and effective even after phasing out of the current time-slice program.

### 6.2.3 Proper layout for Orchard Plantation

Population pressure and higher expectation of people for greater wealth production from land, the local farmers are cultivating hills and hillocks without considering slope gradient and erosion hazards. Over 2320 ha of hilly land in this watershed is currently under lemon and pineapple cultivation in *Balishira* and *Satgaon* hills. Pineapple are cultivated in the hill slope along vertical lines (across the contour), which cause high speed run-off and subsequent soil erosion and land slide.
Demonstration plot for pineapple gardening incorporating contour line layout design, proper weeding and management system, would be established to demonstrate proper cultivation method and train up the planters. A minimum of 8-10 demonstration plots, each of 1-2 ha in size, would be established at *Faizabad*, *Mohazirabad* and *Lainglachhara* areas having good demonstration prospect and accessibility round the year. To ensure people's participation, workshops and meetings would be arranged to impress upon the better production, effective soil conservation and economic benefit of the properly managed cultivation system. Awareness campaign on environment friendly cultivation process would be conducted across the lemon and pineapple growing area. Orchard management extension program (OMEP) to disseminate the proper orchard management technology would be organized within the lemon-pineapple gardening area. Comprehensive training for gardeners using posters, leaflets, booklets would also be conducted along with awareness programs.

### 6.2.4 Rational Use of Water

Water is an indispensable fundamental ingredient needed for cultivation. Farmers bund the *Chhara* to irrigate their lands during dry season. Lemon and tea planters are in favorable position due to high altitude location of their farms. On the basis of water status of *Chhara*, the planters make seasonal temporary earth dams or directly pull water from the streambed. For this upland damming, the farmers of the downstream do not get water for their crops like *Boro* rice or vegetables. It is evident from the land use that within the commanding area of *Jaita* and *Jaag Chhara*, 500 ha and 257 ha lands respectively remain fallow during *Robi* (Winter crop) season due to scarcity of water which are 43% and 23% of total catchment of *Jaita* and *Jaag chhara*.

According to water users, sluice gates would be required on suitable reach of *Chhara* to ensure water for maximum cultivation areas. People attending the project sponsored participatory workshops demanded for sluice gates on *Jaita* and *Jaag Chhara* to meet water need for their dry season crops. Proper use of water will reduce the evaporation, leaching and run-off losses, and at the same time more water could be flowed to *haor* habitats. It is relevant to mention here that a sluice gate has already been constructed on *Boula chhara* and appliances installed to ensure irrigation water for most of the farmers of *Boula* sub-watershed. Early crops like vegetables, wheat, watermelon etc. would be promoted to reduce the pressure on surface water during dry season.

### 6.2.5 Proper use of Herbicides and Pesticides

Herbicides and pesticides are poisonous elements for vegetation and living beings. Wide use of herbicides by tea gardeners to kill/suppress weeds are washed out by rains and carried by run-off water, and ultimately drains to *haor*. Residual actions of herbicides some time kill the valuable vegetation and even affect paddy of *Hail haor* flood plains. Pesticides likewise affect the life of aquatic livings. The workshop participants also perceived that toxic wastes, pesticides and herbicides washed down in the *chhara* hamper aquatic life. It is therefore necessary that agro-chemicals use in the watershed area as a whole is controlled.

Use of agro-chemicals in general should be discouraged and greatly reduced during monsoon. Instead, integrated pest control measures (IPM) are undertaken. Wastes of agro-chemicals such as residue of poison, their packets and bottles, and those of herbicides and pesticides should be dumped in the safe place so that these materials can not spread out through water.

## 7.0 GOALS AND OBJECTIVES

*The Goal of the Watershed management project is to demonstrate on a sub-watershed scale, improved land and water management practices that are conducive to improving the quantity (flow) and quality of water, reducing the sediment inflow into the haor basin, and augmenting soil fertility and agricultural productivity with long term sustainable utility of haor basin as natural fisheries production and development ground. The recommended land and water use practices would be ecologically sound, technically appropriate, socially desirable, and ensure a sustainable use of the overall natural resources of the Hail Haor watershed.*

Specific objectives are:

Objective-1 : Demonstrate ecologically sound, technically appropriate, socially desirable, and sustainable land management practice on sub-watershed scale.

Task-1 : Develop area specific land management technological guide line incorporating proper agriculture practice and awareness campaign to disseminate the same among land users.

Task-2 : Work in collaboration with tea estate authorities to implement ecologically sound land management in the tea estate areas of the water shed.

Tesk-3 : Develop and implement orchard management extension program (OMEP) in the watershed demonstrating sustainable land management for Lemon and Pineapple orchards on sloping land.

Tesk-4 : Policy advocacy to ensure ecologically sustainable agriculture practice and cropping pattern, e.g. prohibiting agriculture on hills/hillocks/valleys steeper than 40% slope gradient.

Objective-2 : Demonstrate ecologically sound, technically appropriate and socially desirable water management practice incorporating wise use of water, logical water sharing and ensure dry season water flow in to the *haor*.

Task-1 : Determine water needs for different crops and ensure enhanced dry season flow to *Haor* through proper land and water use in the upper catchment of the watershed.

Tesk-2 : Promote water sharing and wise use of water through OMEP and awareness campaign.

Tesk-3 : Reforest the denuded catchment and restore riparian vegetation which will respectively reduce soil erosion and facilitate increased percolation storing greater quantum of water during wet season and increase flow during dry season through enhanced seepage., and stabilize the stream banks.

Objective-3 : Demonstrate restoration of wetland and wildlife habitat through re-creation of forest habitat, reduction of erosion and siltation, and improvement of water quality.

| | | |
|---|---|---|
| Task-1 | : | Afforestation in available hills/hillocks/valleys/orchards/homesteads/stream banks on sub-watershed scale. |
| Task-2 | : | Regenerate swamp forest in the wetland area |
| Tesk-3 | : | Create green belt of trees and vetiver hedge along stream banks and denuded hilly terrain. |
| Tesk-4 | : | Demonstrate appropriate plantation layout for orchards through OMEP. |
| Tesk-5 | : | Reduce/eliminate inflow of toxic chemicals in to the stream network and wetlands of the watershed through motivation and awareness campaign as well as through policy advocacy and legal instruments. |
| Objective-4 | : | Demonstrate technically appropriate and socially desirable sustainable use of natural resource of *Hail Haor* watershed through rural development management and active community participation through user group development techniques. |
| Task-1 | : | Develop grass-root Resource Management Organization (RMO) with active participation of the resource user community for *Chhara/ beel* /river sections and an APEX Committee for the watershed as a whole. |
| Task-2 | : | Provide training to the member of RMO on sustainable natural resource development and management, and capacity building for sustainability of the RMO. |
| Tesk-3 | : | Incorporate wise resource harvest through awareness campaign and establishing an agreed code of conduct with the resource users through RMO. |
| Tesk-4 | : | Introduce an efficient community monitoring and on-going evaluation technique of natural resource development program through systematic tracking of activity implementation. |

## 8.0 RESTORATION PLANNING

*Hail haor* watershed with its vast undulating area coverage is a very complex biota having diversified uses of land and over exploitation of natural resources. Type of resources as well as economic status of user communities of the watershed, their origin, customs and religious belief differ with people living at different elevation situations of the watershed. Various criteria are thus required to be considered in regard to restoration of *hail haor* watershed as well as effecting rural development of adjoining villagers. These are:

Restoration Criteria:

- A complete inventory of *Hail Haor* watershed and existing resources
- Thorough analysis of the various climatic factors
- Full picture of the topography and landscape
- Soil erosion and landslide status of hilly terrain
- Status of sediment loading from upper catchment
- Water discharge from *chharas* and seepage from hilly terrain
- Soil Quality
- Water Quality
- Local agricultural practices and cropping pattern
- Current water management practices
- Vegetation including riparian, hilly and aquatic situation, social forestry activity

- Cropping intensity and type
- Tea Estate Management
- Wetland including *haor* and *beels*
- Composition and character of user Community

Rural Development Criteria:

- Socio-economic status of the villagers
- Origin of the community living in the watershed
- Reduction of dependence on natural resource for livelihood.
- Ecologically sound and socially desirable sustainable rural development

## 9.0 WATERSHED ECOSYSTEM MANAGEMENT PLAN

### 9.1 Awareness Campaign

In order to aware the watershed living communities on the functionality of watershed and interactions of the user communities, and also on sustainable natural resource management, strong awareness campaign would be conducted throughout the watershed. To this end, various tools and strategies like - *Uthan Baithak*, village level meeting, b*azaar* meeting, *Baul* song, village d*rama* and rally would be organized. School awareness program and cross visit of the beneficiaries to successful demonstration sites would be organized. Posters, leaflets, pamphlets etc. with environmental messages would be developed and distributed. Depending on the population density, accessibility and clustering of the settlements, the number of meetings and other activities would be decided and conducted. Agreed number of such activities would then be monitored accordingly both on numbers and quantities, and in the agreed manner and time frame.

Based on the intensity of population within the whole watershed of *Hail haor*, about 100 number of such awareness raising basic motivation programs would be conducted allocating 30-40 programs per year. Refreshers program will also be conducted at 3 years interval. Exclusive program with indigenous villages and schools would also be included in the awareness raising activities.

### 9.2 River/Flood Plain Habitat Restoration

River, canals, and *Beels* are the major wetland resources of *Hail Haor* watershed. Significant portions of the rural community are dependent on these watershed resources for their basic livelihood and food security. In general, around 80% protein supply of Bangladeshi people are met from fish source. In the context of *Hail haor*, fish, reeds & grasses, and other aquatic flora and fauna are also important resource that are harvested by *haor* neighbors regularly for their subsistence. In order to support the expanding population, short-sighted agriculture extension programs were undertaken in the past without considering long term damage to ecosystem or natural resource management needs. These activities have seriously degraded wetland habitat and consequently the wetland product output have been reduced considerably. The connectivity among water bodies of different *Beels*, canals and rivers has also deteriorated due to siltation of water courses by sediment load coming from the watersheds through the *Chharas* (MACH-CNRS study).

MACH Project has been working in *Hail haor* and its watersheds to rehabilitate the habitats taking in to consideration the participatory approaches as the most pragmatic way of achieving sustainable result. There are 131 *Beels* (natural depression) in the *Hail haor* and a river (the *Gopla*) also flows

from South to North across the Hail *haor*. There are stream networks from the surrounding hills all over the *Haor* basin but the only connectivity with the river system is through the Gopla river.

Following are the major problems of the river flood plain habitats of the *Hail haor* watershed:

- Massive deforestation in the hilly watershed
- Misuse of watershed hill slopes through soil disturbing cultivation
- Destruction of riparian vegetation exposing stream banks to scouring and erosion
- Siltation of canals, streams, rivers, *beel* beds by water borne silt
- Loss of connectivity of the *Haor* with source river *Kushiyara*
- Destruction of aquatic vegetation and swamp forest of the *Haor* ecosystem
- River/stream bank destabilization due to ground clearance right up to the stream bank

The problems mentioned above are mostly the causes and effects of human actions. For example, siltation is a problem and the causes behind these problems are deforestation and wrongful use of hill slope. In order to restore the river/floodplain habitats of the *Hail haor* watershed, siltation will have to be reduced through aggressive soil and water conservation measures including re-clothing of the catchment with vegetative cover and adopting appropriate land use management & cultural practices. De-siltation will also be necessary to bring back the wetland habitats. To this effect, MACH project has taken program for re-excavation of 40 ha *Beel* and 10 km canals within the Haor basin in the next three years period (2001-2003). The re-excavation program has been planned for execution through community participation in the planning and subsequent management of the re-excavated water bodies. More *beels* and *khals* need re-excavation and these are identified according to the wishes of the community as well as on the basis of technical and strategic considerations.

Reestablishment of connectivity between *Kushiyara* and *Hail haor* is sought to be done though re-excavation of *Shakhaborak* trunk canal and 5 other canals off *Shakhaborak* to *Boro haor*. A total of 30km stretch canal re-excavation will be done which will re-establish connectivity between *Hail haor* and *Kushiyara* river.

To restore and enhance convenient environment of the wetland/floodplain habitat, swamp forest trees like *Hijal, Koroch, Borun. Pitali, sheora, Jarul* 0etc., and reeds like *Murta, Nol, Kkhagra, Ikr* Ikr, *Binna* grass, and Cane will be planted on available swamp land. Protection of 5 ha swamp land in an appropriate location in the *haor* basin will be provided to facilitate recruitment of natural regeneration and watching out vegetation succession. Awareness will be raised among the resource users regarding the importance of, and necessity for such swamp land plantations in fostering fisheries development and attracting local and migratory birds having symbiotic relationship with productive fisheries. Community organizations will be evolved at different tiers of the society and administration to develop, manage and regulate the harvest of natural resources of the *Hail Haor* watershed. These will help restoration/enhancement of woody and non-woody vegetation and also help establishing sustainable management of these aquatic resources.
Riparian vegetation along 25-30 numbers of *chharas* will be restored which will stabilize the *chhara* banks, and also create a woody corridor for wildlife movement. Afforestation will be done in the upper reaches of the watershed that would reduce erosion and increase ground water recharge eventually increasing dry season stream flow and grater depth of water level in the *haor* basin.

Land use management in the hills and valleys will be done through orchard management extension program throughout the watershed. This will ensure optimal and rational use of water, take care of proper land use and reduce siltation of water bodies.
Sanctuaries for wildlife and aquatic livings will be established to enhance the recruitment of fish. MACH project has program to establish 30-35 aquatic sanctuaries within the Haor basin.

Afforestation, regeneration of riparian and wetland vegetation, de-siltation, sanctuary establishment, land use & culture management, water use management and finally, earnest involvement and careful

resource management by the resource users will hopefully restore and enhance the river/floodplain habitat and augmented resource output.

## 9.3 Land Use Management

There are diverse nature of land use in the *Hail haor* watershed. Within the total watershed area, about 36% and 41% of lands are respectively under intensive cultivation of tea and rice-vegetables. Tea plantation within tea estates is done along the contour line. It was reported by James Finlay tea estate management that runoff and splashing effect of rain are not severe in tea gardens even on the slope of the hillocks since tea bushes are acting as the vegetation coverage which intercepts rain drop and enhance the infiltration rate while reversibly decrease run-off. Various land rehabilitation grasses like Guatemala, Citronella are planted in the erosion prone edge of tea gardens. James Finlay PLC already thought of *vetiver* grass as an erosion control measure and a small-scale nursery was established on an experimental basis.

About 4% of total watershed area is covered with lemon and pineapple garden and these sloping lands are erosion prone due to 'across the contour' plantation technique of pineapple cultivation pursued by the garderers. Avoidance of steep slope lands (above 45% slope gradient) for pineapple cultivation, and adoption of contour line plantation technique in substitution of the currently practiced 'across the contour' plantation system is the key to reduce erosion of sloping land. Gardeners interviewed by the project personnel looked shy of adventuring contour cultivation. Adoption of contour planting technique by the gardeners therefore calls for establishment of demonstration plantations by MACH project and establishing superiority of contour plantation technique. In the year 2001, two numbers of contour plantation demonstration plots were established in the upper reaches of *Joita chhara and* they are doing well with encouraging soil conservation and plant growth. A few more such demonstration plantation plots in conspicuous locations are required to be established in the coming years (2002 and 2003) at different cultivation zones of *Hail Haor* watershed so that the local gardeners observe the success and beneficial effects of contour plantation culture, and are convinced/encouraged to adopt this technique.

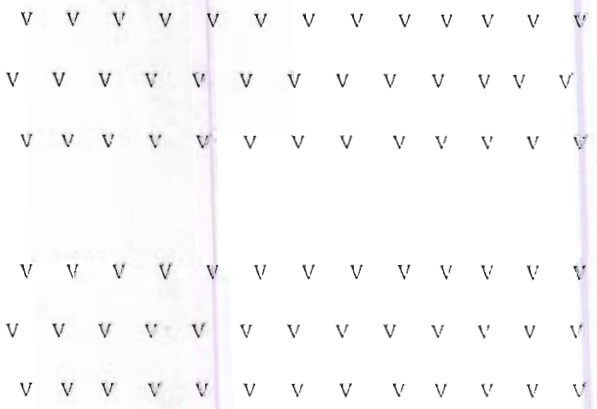


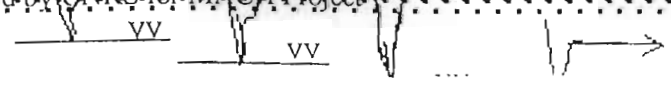
Figure 9: Diagrammatic presentation of suggested planting pattern by Orchard Expert

In case of cultivation on hilly terrain, land should be kept covered as much as possible with vegetation to reduce soil erosion by the rain splashing and subsequent run-off. Inter cropping as well as intensity of cropping should be kept in the purview of these culture practices in the interest of soil and water conservation.

Intensive cropping management plan should be adopted for lemon and pineapple cultivation on undulating land of upper catchment of watershed. Deformation of natural landscape is mostly done by the lemon and pineapple planters that leads to tremendous soil erosion and degrading the quality of top soil. This has got to be stopped/regulated through appropriate intervention.

To avoid erosion provoking traditional layout pattern of 'across the contour' planting of pineapple on sloping land, the following layout design should be followed which would result in less erosion, greater soil and water retention, and higher fruit production. Farmers think that planting a single row along contour line might tilt the pine apple plant downward by run-off thrust or fruit pressure. This is a presumption and not based on experiment. However, if any such tendency is exhibited by contour





plants, this can be overcome by planting two to three lines of pineapple plants close by which will then support each other. Plants in alternate lines should be in staggered layout. The walk row between planted rows should be as narrow as possible but sufficiently spaced to allow access without too much soil exposure. Figure 9 shows the diagram of plantation layout. Suggested spacing is 0.3m between plants in the line, 0.3m between two adjacent lines and 1.0m between two planting beds.

Orchard expert suggested many appropriate management systems. Terracing could be done to make effective use of irrigation water and fertilizer but terracing on steep slope is not permissible. However, when terracing is done, to stabilize the edges of each step, hedgerow of *Boga madula,* lemon or vetiver grass could be established. It should be borne in mind that slope >45% is not suitable for pineapple cultivation.

Orchard management extension program (OMEP) to disseminate proper orchard management technology would be organized within the lemon-pineapple gardening area. Demonstration of pineapple and lemon gardening incorporating less erosive tools and erosion protection measures will be established. Around 30# of pineapple & lemon demonstration plots will be established which would cover Faizabad, Alia chhara, Mohajira bad, Bishamoni and Laingla chhara areas. Comprehensive training for gardeners using posters, leaflets, booklets and field demonstration would also be conducted along with awareness programs.

Less water requiring crops like- wheat, maize etc. would be introduced in the water scarce area that will be conducive to increased water flow into *hail haor*. For total watershed of *Hail haor*, about 50-60 nos. of dry farming demonstration plots would be set up for the dissemination of farming idea. Agricultural extension services and its awareness programs on the relevant topics would be conducted in support of the dry farming.

## 9.4 Water Use Management

Water needs, accessibility to water sources, water use and water sharing are of crucial importance in determining the soundness of the watershed function. Habitats formed depending on the availability of water and accordingly all living beings used to gather around the water sources or at least a means of using water. *Hail haor* watershed is complex having undulating landscapes, intensive use of land, diversion of water at different elevation of watershed. Water from the upper catchment drains downward through streams and over land flow. During flowing from its origin to down basin, it creates habitats, and used by flora and faunal community and various human uses. The interaction between water and soil causes soil erosion and it should be considered in the water use management. Dry season water flow is very important in respect to agro-based rural Bangladesh. The high yielding rice variety of Bangladesh is growing during dry season which require substantial volume of irrigation water.

Data shows that about 6000 million $m^3$ of water flow into *Hail Haor* through the *Chharas* per year. The dry season water flow is however decreasing due to lack of recharging of underground water table. In order to irrigate the cropping land during dry season, earthen cross dams are constructed on the *chhara* at its different reaches. Diversion of water flow leads to less water flow in to *Hail haor*. It has also been found that farmers of down reaches are not getting water adequately due to establishment of dams on the up stream of *chhara*. Pragmatic water sharing is thus very important for dry season farming. Water loss by runoff and evaporation during irrigation is tremendous in rural Bangladesh in dry season. Awareness program and agricultural technology regarding effective irrigation would be disseminated to the farmers for the reduction of dry season water losses. Sluice gate would be established to make proper distribution as well as to reduce misuses of water. Water reservoirs or ponds would be established and also revived for ensuring irrigation.

Interventions like afforestation, regeneration of riparian vegetation, reduction of water losses through run-off etc. are the ways to increase dry season water flow; these interventions will be adopted.

Introduction of less water loving crops within the water scarce area would be highly effective to reduce the water needs; these will be encouraged. Orchard management extension program also would be helpful for rational distribution of surface water. To this effect, appropriate extension service will be made available.

## 9.5 Fisheries Management

The rich fisheries of *Hail haor* are degrading day by day because of a number of exacting reasons. Of these, habitat degradation could be termed as a formidable cause for declining fisheries. The siltation from the upper catchment is responsible for the siltation of the water bodies. Loss of connectivity is another crucial factor degrading the habitat. Lack of proper management and over exploitation are another important causes for declining fisheries. In this section, the management aspect is considered in greater details.

The local resource users will manage the fisheries of the *Hail haor* watershed. The project intends to find a way of management along with the stakeholders through participatory planning which will include periodic ban on fishing, ban on fry harvesting, stop de-watering of deep water bodies and others as decided by the resource users. Awareness campaign will be conducted through out the watershed explaining the fisheries production system, sustainable harvesting, importance of brood stock, connectivity, significance of over-exploitation etc. Management Manual in a simple and local language would be prepared highlighting the fisheries management aspect. An agreed guideline would be prepared and provided to the community resource managers. The plan shall be implemented by the community. The community and/ the resource users of a water body (*Bee*/Canal/ River section) will be organized and a formal Resource Management Organization (RMO) will be formed. This is the grass root level committee. For the water bodies, those are cross boundary to these resource bases, a second tier committee will be formed as regional committee. This committee shall be responsible for regional management of the water bodies. Finally, a *Hail Haor* Apex committee ll be formed for the watershed that will handle the policy issues.

Members of the RMO will be provided with required training on the natural resource management and capacity building for the sustainability of the committee.

Water serves as a habitat for fish. Conversely, fish production depends on the quality and quantity of habitat. With an increase in habitat area, fish can have more area for feeding and spawning, and will naturally produce greater numbers of offspring. This increase in habitat area will then be able to support the increased demands of larval rearing and growth. Similarly, with a longer duration of habitat, fish are allowed a longer period for feeding and growth. In other words, the larger the habitat area and the longer the inundation period, the greater the fishery production.

Natural recruitment through successful migration of fish from wintering habitats to breeding and feeding habitats is another key factor for sustenance of floodplain fisheries production. Migration occurs during the pre- and early monsoon season, when the rain starts, and river level begin to rise. During this time, fish begin migrating from their over-wintering habitats (deeper waters in *beel*, *pagars* and rivers) to inundated floodplain lands. Floodplain lands serve as common spawning, nursery and feeding habitats for most of the floodplain species. The productivity and bio-diversity of floodplain fisheries, therefore, is not only dependent on and influenced by the area and inundation duration of the habitat, but also upon the successful migration of fish between rivers and floodplains.

Ecological management of floodplain fisheries is major focus of watershed management. Therefore, project activities will address the management of the ecosystem and emphasize habitat restoration and enhancement, conservation of species, and prudent use of resources. Short description of three restoration/enhancement interventions is indicated below:

- **Fish Habitat Restoration and Enhancements:** Due to anthropogenic and natural causes, the qualitative and quantitative features of *Hail Haor* fish habitats have been degraded. The watershed management project would, therefore, emphasize activities contributing to the

restoration and enhancement of the quality of the habitat so that the natural and self-regenerating system of capture fisheries is ensured. Such activities would include desiltation of canals and *beels*, wetland afforestation with water tolerant species, and fish-friendly operation of sluice gates and re-establishment of connectivity between Kushiara river and Hail haor.

- **Fish Sanctuary/Wintering Refuge:** The entire fish population experiences a very crucial time during the dry season when most of the fish habitats are dry or nearly dry. In this period, fishing pressure goes up, water quality degrades and water abstraction peaks. In combination, all of these factors make the fish vulnerable to higher natural and fishing mortality. To address these issues, sufficient extent of dry season refuge areas need to be maintained where a mix of diverse species in reasonable quantities can survive and attain maturity. The dry season refuge area can be created through re-excavation of *beels*, *pagars* and canals within the project area. Development of small fish sanctuaries in river pools and *beels* with brush shelters can enhance habitat quality and help preserve parent stock of fish, shrimp and other aquatic biota. The MACH project would motivate the community to recognize and respect the refuge area so that parent stock is conserved during the dry season. The overall effect would be the re-population of the system for the next monsoon.

- **Wise Use/Sustainable Fishing:** Sustainable fishing is very important to ensure continued supply and productivity. Without it, natural fisheries collapse. Sustainable fishing of course does not mean complete discontinuation. Rather, it should comprise flexible fishing regulations which the communities themselves can , regulate and practice. The regulations could be time specific, gear specific and even location specific. For example, fine mesh seine net fishing could be stopped for 4-6 weeks at the beginning of monsoon flooding. This would allow many species to breed and many young fish to put on quick, early growth. Use of the *current net* (monofilament nylon gill net) could similarly be restricted for specific time period in defined areas, as deemed appropriate. Sustainability of resources largely depends on conservation, enhancement and harvesting. It is only possible when the local users, who depend on the resource for their livelihood, are educated, motivated and given the responsibility of managing their own resources. They are of course aware of the fact that, if the resource base is lost, their livelihood is threatened. But driven by extreme poverty and lack of alternative income source for subsistence, they painfully violate the basic norms of fishing. The project should therefore encourage the users/fishers to adopt wise resource use practices in their water bodies and simultaneously also cater for tiding over fisher's sustenance during hardship period when they are not fishing.

## 9.6 Habitat Restoration

### *9.6.1 Re-generation of Vegetation*

Based on the existing land culture and vegetation coverage and its management protocol, 9 different types of habitats are recognized in the domain of Hail *haor* watershed. These are:

1. *Beel*
2. Paddy Fields
3. Human Settlements
4. Riparian Zone
5. Lemon and Pineapple Garden
6. Tea Garden
7. Rubber Garden
8. Natural Forest
9. Plantation Forest

With no exception, all these habitats are continually degraded due to both natural and man made causes. Among the natural causes, soil erosion, land slides, cyclonic storms, drought, catastrophic floods etc. are the common happenings, while land conversion and unwise land use, deforestation,

over exploitation of natural resources are the common man made causes. Reestablishing the ecological balance and mending the damages already done are the practical ways and means to habitat restoration.

For wildlife habitat restoration, natural and plantation forest cover would be conserved and augmented. About 50% of the water outflow from *Lawachhara* and *Satgaon* forests is draining into *Hail haor*. Forest management should therefore address problems of soil conservation and watershed management through awareness campaign among the forest resource harvesters and forest neighbors, as well as through stringent enforcement wherever needed. Deforestation, hunting and shooting, over harvesting of resources like bamboo, sun grass, cane etc. should be discouraged or even banned with appropriate provisions of compensatory measures made for the owners and users, should such measures be deemed necessary.

Some 448 ha and 1305 ha of respectively of plantation forests and natural forests exist within the tea estate areas located in the command area of *Hail Haor* watershed (Annex-6). Scattered bamboo and uneconomic bushes with malformed, unimportant sparse trees are primarily the main vegetation of these natural forests, while the planted forests were raised principally with exotic tree species like E*ucalypts, Akashmoni, Mangium, Teak* etc. As for improvement of the natural forests, the tea garden owners would be motivated to introduce indigenous tree species preferably through enrichment planting and also through promotion of undisturbed natural regeneration process. Both Plantations and natural forests of the tea estates should be classified and declared as forest from which economic return would be harvested after certain years but managed scientifically as forest stands. The project would assist tea estates with technological and scientific inputs regarding afforestation and aided natural regeneration techniques.

Riparian Corridor: For maintenance of ecological balance and its sustainability in a given geographical situation, appreciable vegetation cover is indispensably required. Degradation of riparian corridor by both natural and man made causes result in isolation /degradation/destruction of the habitat. Naturally, the ecological balance is also disturbed. Because of the degradation and most often isolation of the habitats, the wildlife movement became restricted, and they become endangered due to shortage of food in limited area and lack of secured shelter. In fact, shortage of food and absence of secured shelter in the past led to the extinction of many wildlife species from the *Hail Haor* watershed. If the situation continue to deteriorate, many more species of wildlife will be threatened with extinction. Riparian vegetation to function as a corridor for wildlife movement is thus important for establishing connectivity among different habitats and should be restored under the MACH project.

*Hail haor* lake is fed by 59 *Chharas* of varying width, length and water flowing status, all draining from the surrounding watershed. Of these *Chharas, Bilas, Udna, Laingla, Alia, Jaita, Boula, Bar, Burburia, Jaag, Shaon* are the perennially water rich streams. Banks of these *chharas* are in bad shape due to excessive erosion which is the consequential effect of destruction/degradation of riparian vegetation. In order to restore stability of the *chhara* banks, appropriate vegetation cover is needed and should be restored under the project. The project seeks to establish three-storied vegetation canopy of tall trees, medium trees, and shrubs & ground vegetation along 30 numbers of important *chharas* to increase the soil holding capacity of the *chhara* banks. Indigenous tree varieties viz. *Koroi, Chikrashi, Garjon, Gamar, Rongi, Rata, Jarul, Arjun, Kadam, Kainjal,* and domesticated exotic species like *Mahogony, Akashmoni, Mangium, Eucalyptus* would be planted along the bank of the *chharas*. For the lower reaches of *chhara,* submersion tolerant species like *Hijal, Koroch, Pitali, Borun, Jarul, Arjun* are suitable. *Futki, vetiver* grass and other floor species suitable for bank protection may be tried.

About 350,000 tree seedlings will be required for restoration of 175 km length *chhara* bank riparian corridor located in the watersheds of *Hail haor* (considering two rows of plants on either bank). The plantation spacing for timber will be 2x2m and that for fruit species will be 4-6m in lines. Riparian

vegetation restoration program in the upper reach of *chharas* flowing through tea gardens would be undertaken as a collaborative program of the project and the respective tea estates.

**Seedling Height Specification for New Plantation:** Since *chhara* banks are highly disturbed places because of stray cattle grazing, plantation on riparian corridor will be subjected to severe cattle damage and unregulated human activities. To ensure strategic protection of the planted seedlings, bigger seedlings above man-height (more or less 2 meter high) shall be planted so that the tender foliage of the saplings are beyond the ordinary reach of the cattle and hence safe from cattle browsing. Adherence to the prescribed height specification of planted seedling is key to the success of plantation program on disturbed public places, and must be remembered and earnestly followed.

**Contour Hedgerow Establishment:** The *Hail Haor* watershed is a unique undulating compact landscape that lay surrounding the *Haor*. Run-off is the main critical factor responsible for soil erosion and landslide. To reduce the quantum and speed of surface run-off, and to accelerate the water infiltration into the sub-strata thereby recharging the ground water table, live hedges of *Boga madula*, Lemon and Vetiver grasses and other ground flora would be established on the hill slopes in contour line layout. In the orchards, *Vetiver* hedgerow established will reduce sheet and gully erosion. *Vetiver* slips/tillers, seeds of *Boga madula* and others would be planted/sown in double lines on the steep slopes and erosion/landslide prone areas. Prior training of the field workers and supervisory staff of all the concerned gardening agencies would be necessary to layout and establish good hedgerow planting in contour line and MACH project will endeavor to impart such technical training. A number of nurseries (not exceeding 10, each having 30-40 decimal land) would be established to produce and supply requisite *vetiver* slips/tillers. *Boga madula* seeds would be procured locally from the tea estates where this species is grown abundantly as a nurse crop. Land renting, land preparation, seed/seedling collection would be the prerequisite for nursery establishment.

**Afforestation and Reforestation:** Multi-storied vegetation cover of tall, medium, and shrubby trees with ground cover proved excellent vegetative protocol for soil conservation and prevention of rapid run-off. The barren hills and hillocks of the *Hail Haor* watershed upper catchment areas are currently contributing to soil erosion and land slide. These delicate lands would be brought under afforestation and reforestation program under the project in collaboration with the landowners. Status of the indigenous parent vegetation i.e., species diversity, abundance, historical perspectives etc. would be reviewed prior to embarking on afforestation program. According to tea estate managers and lemon-pineapple gardeners, about 2000 ha of lands is lying barren in various gardens which would require about 5 million tree saplings to cover these up with plantation. Indegenous tree species like *Chapalish, Chickrassi, Garjan, Telsur, Champa, Rongi, Jarul, Sil Koroi*, and domesticated fast growing and high valued exotics like *Mahogony, Akashmoni, Mangium*, and *Teak* should be the choice of species. Afforestation in the encroached *Khas* and Tea estate lands would be collaborative in respect of investment and profit sharing. The management of forest would be regulated through RMO and the global *Hail haor* watershed management resource committee (the LGC).

**Swamp Plantation:** Inside the *Hail Haor* basin, there are some raised land, locally called *Kanda/Kandi*. These are currently dominated by natural growths of *Dholkalmi* (*Ipomea fistulosa*) and *Hogla* (in the dry season only). In order to improve *Haor* ecology and to enhance quality of habitat for fish and birds, as well as for creating new resources for the neighboring people, swamp forest will be recreated along the banks of the *chharas* and on the *kanda* land. Aquatic trees viz. Hijal, *karach, kadam, jarul, Pitali. Borun. Sheora, and reeds like Nol, khagra, hogla, chailla, binna* grass etc. would be re-introduced to improve aquatic habitat. Some planting on *Kagaurar kandi,*and *Ichamati chhara* banks were done in 2001 under MACH-CNRS activity programs. To enhance the quality of aquatic habitat, about 100 ha of fallow raised lands would be planted through swamp land afforestation program with Hijal, Koroch, Borun, Pitali, Cane and aquatic reeds including Murta, *nol, khagra, Ikr*. Well organized RMO would be formed with the resource users for each of the resource base to ensure safety and sustainability of the resource generated.

for overall degradation of natural resources through over exploitation of resource, 9 misuse of resource base- the land, and degradation of habitats for plant and animals. A combination of rectification portfolios including conservation practices, wise use of land, and reduction of pressure on land are necessary to restore the hail *haor* watershed.

Of the population of watershed areas, above 92% are living in the villages. The rural population are mostly dependent on various form agricultural activities and fishing in *Hail haor* lake and tributaries for their subsistence. A significant number of people in the upper catchment including indigenous community are involved in cultivation of hilly land to earn their livelihood. Intensive fishing, unwise cultivation on delicate sloping landscape and unregulated harvesting caused declining of watershed resources and degradation of the resource base. Income generating activities (IGA) to off-set total dependence on resource harvesting and hill cultivation are required to be introduced in the rural areas of *Hail Haor* watershed to reduce human pressure on the resource base and halt its degradation. It is seen from the RRA report for Sreemongol conducted by MACH project that the population surrounding the *Hail haor* basin mostly chosen cattle farming, poultry, orchard raising and tree plantation as the alternative income generating activities. Technical support would be needed by them to create efficient manpower and adoption of right technology for the income generating activities followed by soft term financial support. The project would endeavor to provide these inputs.

Since women constitute 48% of the total population of the project area, the female folks of rural areas would be involved in tangible alternative IGAs. Entrepreneurship would be developed among the landless poor community. IGA like poultry, duckery, rearing of milch cow, cattle fattening, handloom, cottage industry, handicrafts, paddy husking etc. would be introduced with proper training to the entrepreneurs and assisting with marketing. Soft term financial assistance for these activities would be needed and provision made in the project programs.

### 9.8 User Management Group Development

Management and protection of natural resources by the user community is the pragmatic way to make such resources sustainable. But prevalence of poor literacy in the rural areas is a fundamental problem for such organized participatory development. It is necessary to aware and educate the user community about the present perspectives of the natural resources around them and the impending need for their proper development and management exercising due restraint in resource harvesting. The project will focus its full endeavor to achieve that objective.

*Hail haor* watershed provide livelihood security for 220,000 users. Forests, *chharas*, hills, floods, fish, aquatic vegetation etc. are the basic resources of the watershed. It was the consensus report in the participatory workshop that natural resources are declining at an alarming rate due to unwise exploitation along with various other causes mentioned earlier. It is essential to enhance the reserve of natural resources with the help and participation of the user community. MACH and its watershed management project concentrates on, and intends to work for sustainable and equitable management of the overall watershed resources.

Development activities conceived for *Hail Haor* watershed improvement like rehabilitation of water bodies, connectivity improvement, regeneration of riparian vegetation, erosion protection etc. would be implemented with the active participation of user groups. Resource Management Organizations (RMO) would be formed involving all the resource users of surrounding areas (villages) of the resource base to manage the resources along with constant participatory monitoring and evaluation. For instance, a RMO would be formed for each "*Beel*" or "*Chhara*". The resource users of the surrounding villages like fishers, farmers, laborers, teachers, elite and other interested citizens would be inducted in the RMOs. Standard procedure for stakeholder analysis and their incorporation in the RMOs would be ensured. A second tier committee, Union Resource Management Committee (URMC), would be formed for each Union and that would include representation from all the RMOs of the Union. While the RMOs would take care of individual resource base and resources, performances of all these RMOs would be taken care off by the URMC. A final APEX Committee for

the *Hail Haor* watershed would be formed at the Upazila level. This APPEX committee would include local government representatives (CUPs), *Upazila* level GOB officials of concerned departments, NGO development agencies of the watershed. This body, called the Local Government Committee (LGC) shall bring management issues to the notice of the relevant central government authority (Ministry) concerned with natural resource management of the watershed. When fully worked, a total of 50-60 RMOs, 7 URMC and an APEX committee (LGC) would need to be formed for the entire *Hail haor* watershed catchment and *haor* basin.

## 9.9 Monitoring

In order to keep proper track of the direction of program activities towards reaching the goal, regular monitoring would be required and should be conducted. The intermediate findings from the monitoring data would be analyzed, on-going evaluation done and appropriate management prescriptions would be adopted accordingly. Evaluation of the project would be based on the baseline scenario and impact monitoring. The following monitoring tools would be used:

i) *Photo Points:* The *chhara* banks are in extremely bad shape and highly degraded due to unregulated and over exploitation of riparian and upland vegetation. Photo points at 1km distance apart are permanently fixed on the *chhara* bank by fixing T-shaped RCC (Reinforced Cement Concrete) pillars and photographs showing existing bank condition of *chhara* at these fixed points would be taken which will serve as a baseline status of *chhara* bank. Such photographs, facing both upstream and downstream directions (from thalweg of steam to terrace) of the concerned *chhara,* would be taken. The perspective of pictures is to show the status of bank along with riparian vegetation before the project and with the project intervention, at different stages of project life.

ii) *Water Discharge:* Hydrology of *Hail Haor* watershed is directly influenced by the drainage of hilly streams and surface run-off from the watershed. Out of 59 chharas, big and small, draining to the *Haor,* about 20 # representative *chharas* will be selected for water discharge monitoring. Float method or flow meter will be used to measure water discharge. The year round water discharge monitoring would be conducted at 7 days interval.

iii) *Sediment Load:* To measure the sediment load of *chhara* water, water sample will be collected from the *chhara* during water discharge data recording. Standard hydrometer method for measuring the sediment particles of water would be followed for assessing suspended silt carried by flowing water.

iv) *Intensive Study of Sediment Loading:* To study the intensity of sediment loading and out flow from varying sub-watersheds, intensive monitoring would be conducted on the selected *chharas*. For such intensive study, the sub-watershed might be divided into segments based on the vegetation status and land use. The data would be collected in 3 or 6 hour intervals for a week which would be continued from early monsoon to late monsoon i.e. 3 rounds in the monsoon (May to August). The protocol for sediment loading plus the rainfall data collection will be followed for comparative sediment loading study.

v) *Rainfall:* Rainfall would be measured for every sub-watershed by setting rain gauge in the sub-watershed area. During sediment monitoring rainfall data would be collected simultaneously with intensive sediment loading data collection.

vi) *Land Use Survey:* Land use survey is a very important task for comparative studies of the outflow and sediment load of sub-watersheds because land use variance would make a lot of difference in this particular parameter. Erosion intensity is directly related with land use pattern. Land use survey for each *chhara* will be done using the *Mouza* maps for indicating land use locations.

vii) ***Vegetation Monitoring:*** To study the impact of intervention on watershed vegetation, regular monitoring is crucial. Establishment of plantation, introduction of resource management techniques, awareness building about hazardous land use etc. would change the scenario of flora fauna of the watershed. Vegetation survey would be conducted for keeping track of the floral status and chances in two seasons of the year. Standard methodology will be employed to enumerate the species and closely follow the changes in the vegetation. Transects will be carefully drawn covering all categories of habitats of watershed.

viii) ***Wildlife Monitoring:*** Wildlife monitoring is important to understand the impact of vegetation changes on wildlife population and to assess the achievement of watershed management project in this regard.. Wildlife monitoring will be conducted in the same transect as for vegetation. Wildlife species including birds, mammals, reptilian will be surveyed along assessment of abundance.

ix) ***User's performance monitoring:*** The objective is to assess performance of the user/management groups (RMOs) formed locally as a prelude to community participation in the program management and performance monitoring. The goals and objectives of the project have been set, and implementation mechanism designed with the expectation of motivating willing participation of resource users towards conservation and development of the watershed resource, and ensure their security and sustainability. The project activities including formation of the resource user's groups are subjected to participation and performance of the resource users. The agreed upon intervention agenda would be implemented through these groups. Advancement of the project activities depends on the earnest participation and active performance of these groups. Besides, the management aspects of the resources would be disseminated, implemented and monitored through these groups. Project performance is thus directly related to the group performance. Tracking of these performance call for systematic monitoring of the performance.

Following indicators would be used for monitoring the user group performance.

| Activity Indicator | Measurable Indicator |
|---|---|
| • Increase active participation of resource users in management | • Number of participants from stakeholder groups attending discussion meetings |
| • Better understanding of natural resources production system | • Number of awareness campaign organized |
| • Development of agreed code of conduct for resource harvest | • Code of conduct for exploitation of<br>– Fisheries resource<br>– Other aquatic flora or fauna resource<br>– Forest product<br>Has been prepared |
| • Agreed code of conduct for land use, agriculture practice and cropping pattern | • Agreed code for<br>– Land use<br>– Agricultural practices including Pineapple, Lemon etc.<br>– Other cropping pattern<br><br>Has been developed |
| • Water sharing protocol | • Water use protocol for<br>– Lemon/ha |

| Activity Indicator | Measurable Indicator |
|---|---|
| | – Paddy/ha<br>– To *haor* basin<br>Has been finalized |
| • Community monitoring & evaluation (M&E) | • Modalities finalized and M&E done according to time schedule |

## 9.10 Evaluation

Evaluation of the activities implemented under the project would be carried out basing on the baseline data and scenario, and the changes that had taken place through project implementation. In this regard, socio-economic condition, biological production and physical features would be monitored all throughout the project period and on-going as well as 'end of the project' evaluation will be carried out. Fisheries, hill cultivation, forest coverage, riparian and wetland vegetation, wildlife, hydrology and water discharge, sediment , and the whole gamut of related aspects would be taken care off under the project program.

| Activity Indicator | Measurable Indicator |
|---|---|
| • Increase vegetation coverage, species diversity and abundance | • Ha / km of vegetation cover established<br>• Number of species introduced<br>• Abundance |
| • Increase biological diversity and production | • Nature and character of biological diversity introduced<br>• Per ha increased production of<br>– Fish<br>– Other aquatic resource<br>– Agriculture production<br>– Agro-diversity introduced<br>– Wood stock generated |
| • Decreased erosion, siltation | • Sediment load compared to baseline data<br>• Siltation difference |
| • Increase dry season water discharge | • Water discharge<br>– From upper catchment<br>– From middle reach<br>– In *Haor lake* |

## 9.11 Adaptive Management

The principal tool of adaptive management is systematic monitoring that measures progress over time towards a desired goal. The data and information derived from monitoring of various component activities provides the necessary information to allow the project management to adapt goals and objectives to achievable targets and cater for unforeseen events.

A fundamental concept in watershed management is adaptive management which tells: learn as you proceed and make changes as needed'. Successful implementation of adaptive management requires management to take innovative actions while providing institutional patience and stability. The experimental nature of adaptive management requires that managers and politicians redefine success

so that learning from error becomes an acceptable part of the learning process. In addition, information must be collected and analyzed over time frames that often exceed the typical tenure of political decision-makers.

Adaptive management also needs to be predicated upon clearly established goals and decision criteria that will allow for accountability and also evaluation of how well the set goals are met. Furthermore, the goals must be compatible with natural processes, existing or achievable technology, and social norms. One of the fundamental obstacles in the way of effective implementation of adaptive management is an agreed-upon definition of the term, and how or if adaptive management changes should be implemented.

The application of adaptive management decisions and actions will show greater success in resolving natural resource management conflicts if it is accepted as the link between scientific knowledge and methodology, and resource management. Implementation of adaptive management as a problem-solving process requires flexibility and change when problems demand effective and workable solutions.

Fundamental ecological principles show how nature uses adaptive management in most biological and social systems. Recruitment and adult population patterns are usually mismatched (recruitment levels exceed ultimate adult population levels), and plant communities develop through several serial stages. The current conditions do not predict the biological and social dynamics that create change. Wise management is based on dynamics rather than current states because dynamics determine tomorrow's state.

Managing the dynamics of ecosystem restoration means adapting objectives over time to changes that cannot be predicted or even adequately anticipated today. Adaptive management is the singular element for managing the natural ecosystem to reach the desired goals. Achieving the goals of Watershed Management Project means using management tools in different ways over time to adapt to changing ecosystem conditions, both physical and social. It also means adopting new tools from scientific advances in the course of time to constantly improve understanding and management actions.

### Performance Indicators

Performance indicators are measurable variables that help to assess changes of parameters over a period of time. Five activity indicators have been identified to measure the success of the program. The activity indicators are indicated below:

| Activity Indicators | Measurable Indicators |
|---|---|
| • Increase dry season water flow to *Haor* | • Water discharge through stream |
| • Decrease erosion | • Sediment load in the discharge |
| • Decrease siltation | • Deposition in the wetland bed |
| • Increase forest coverage and canopy | • Forest canopy and plantation area measurement |
| • Increase wild life corridor | • Measure riparian vegetation both in canopy coverage and spatial extent |

## 9.12 Activity Plan

Table 127: Watershed Restoration Plan Targets

| ACTIVITY | TARGET | 1st Year | 2nd Year | 3rd Year | 4th Year | 5th Year | 6th Year | 7th Year | 8th Year | 9th Year | 10th Year | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Community Awareness* | | | | | | | | | | | | |
| ☐ Number of Meeting | 100 | 30 | 30 | 40 | 30 | 30 | 40 | 30 | 30 | 40 | | 3 year rotatio |
| ☐ Number of Participants | 20000 | 6000 | 6000 | 8000 | 6000 | 6000 | 8000 | 6000 | 6000 | 8000 | | |
| Participatory Community Planning Workshop (nos.) | 10 | 3 | 3 | 4 | - | - | - | - | - | - | - | Findings fro MACH PCP w be used for lo reach manage |
| *Training and Demonstration* | | | | | | | | | | | | |
| ☐ Staff Training | | | | | | | | | | | | |
| – Training on watershed resource management | Once | Once | Re-fresher | | | | | | | | | |
| – TOT | Once | Once | | | | | | | | | | |
| – Study tour (nos. of staff) | 10 | | 10 | | | | | | | | | |
| – Collaborating higher education program | 1 | | | | | | | | | | | |
| ☐ Training to Users | | | | | | | | | | | | |
| – Nos. of training require for RMC | 60 | 20 | 20 | 20 | 20 | 20 | 20 | - | - | - | - | Training will provided for CR and BRMC members; A refresher also w be provided fro year |
| – Nos. of participants | 1200 | 400 | 400 | 400 | 400 | 400 | 400 | - | - | - | - | |
| ☐ Demonstration of Farming | | | | | | | | | | | | |
| – Nos. of Pineapple and Lemon Demonstration Plot | 30 | - | 10 | 10 | 10 | - | - | - | - | - | - | 15 pineapple & lemon demo pl would be ma |
| – Area under Orchard demonstration plot (Ha) | 15 | - | 5 | 5 | 5 | - | - | - | - | - | - | |
| *Nursery Development* | | | | | | | | | | | | |
| Nos. of Vetiver, boga maudula & citronella nursery | 10 | 5 | 5 | - | - | - | - | - | - | - | - | |
| Ha of land for Nursery | 1.2 | 0.6 | 0.6 | - | - | - | - | - | - | - | - | |
| Nos. Tree (Terrestrial & aquatic) nursery would be developed | 2 | 2 | - | - | - | - | - | - | - | - | - | Nurseries woul established i terrestrial & wet of Hail haor |
| Ha of Tree Nursery | 1 | 1 | - | - | - | - | - | - | - | - | - | |
| *Riparian area re-vegetation* | | | | | | | | | | | | |
| ☐ Kilometers of stream bank re-vegetated | 175 | - | 25 | 25 | 25 | 25 | 25 | 25 | 25 | Needed gap filling | | Total require k riparian would varied accordin PCP finding |
| ☐ Number of Riparian Trees | 350000 | - | 50000 | 50000 | 50000 | 50000 | 50000 | 50000 | 50000 | - | - | |
| ☐ Area of Vegetation (Ha) | 42 | - | 7 | 7 | 7 | 7 | 7 | 7 | - | - | - | |
| *Resolved Management Organizations* | | | | | | | | | | | | |
| ☐ Nos. of RMC would be formed | 50 | - | 10 | 10 | 10 | 10 | 10 | - | - | - | - | |
| ☐ Number of Resource Maps would be formed | 50 | - | 10 | 10 | 10 | 10 | 10 | - | - | - | - | |
| *Upland Management Practices* | | | | | | | | | | | | |
| ☐ Hectares of upland would be re-vegetated | 1000 | - | - | - | - | 200 | 200 | 200 | 200 | 200 | - | Saplings wi supplied fro project's nurs |
| ☐ Nos. of Buffer Strips | 200 | - | 10 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 15 | Slips/seeds w supplied fro project's nurs |
| ☐ Area under improved | 56000 | - | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 | 7000 | - | |

| ACTIVITIES | TARGET | 1st Year | 2nd Year | 3rd Year | 4th Year | 5th Year | 6th Year | 7th Year | 8th Year | 9th Year | 10th Year | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| management (Ha) | | | | | | | | | | | | |
| Ha of lemon & pineapple area covered by Orchard Management Extension Service (OMEP) | 2300 | - | 700 | 800 | 800 | - | - | - | - | - | - | Extension serv will be provid continuously u the project phas |
| *Middle & lower Reach Management Practices* | | | | | | | | | | | | |
| □ Dry farming demonstration (nos.) | 60 | - | - | 10 | 10 | 10 | 10 | 10 | 5 | 5 | - | - |
| □ Area of dry farming demonstration (ha) | 18 | - | - | 3 | 3 | 3 | 3 | 3 | 1.5 | 1.5 | - | |
| □ Ha of low land re-vegetation (*hizal, koroch, nol, khagra*, and other reeds) | 10 | - | - | 1 | 1 | 1 | 1 | 2 | 2 | 2 | - | Saplings wil supplied fro project's nurse |
| □ Ha of wetland under natural preservation | 5 | - | - | - | 2 | 2 | 1 | - | - | - | - | Consensus buil during the 1st t yrs |
| *Monitoring* | | | | | | | | | | | | |
| Water discharge | Contins | Contins | Contins | Contins | Contins | Contins | Contins | Contins | Contins | Contins | Contins | 20 chhara woul monitored for discharge & sediment load |
| Sediment Loading | Contins | Contins | Contins | Contins | Contins | Contins | Contins | Contins | Contins | Contins | Contins | |
| Intensive Sediment Monitoring | 3 rounds/ year | 3 rounds | 3 rounds | 3 rounds | 3 rounds | 3 rounds | 3 rounds | 3 rounds | 3 rounds | 3 rounds | 3 rounds | This will be conducted dur monsson |
| Vegetation Monitoring (Seasonal) | 2 rounds/ year | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds during & wet seaso |
| Wildlife Monitoring (Seasonal) | 2 rounds/ year | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | 2 rounds | |
| *Chhara* Bank Monitoring (times) | 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Chhara bank w be monitored km interval w will be interv |
| Performance Monitoring | | | | | | | | | | | | |
| Impact Analysis and Adaptive Management: Impacts of the conducted interventions would be analyzed from the 3rd years to 10th year of the pr and accordingly necessary adaptive management would be taken. | | | | | | | | | | | | |
| *Reporting* | | | | | | | | | | | | |
| Baseline Report | Once | - | Once | - | - | - | - | - | - | - | - | After compl the baseli monitori |
| Technical Report | 4 | - | 1 | - | 1 | - | 1 | - | 1 | - | - | Technical r based on the years moni data woul prepare |
| Annual Report | 10 | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Annual re mentioni progress o last year w prepare |
| Final Report | 1 | - | - | - | - | - | - | - | - | - | 1 | Final Repo be publishe completion projec |