

**Evaluating management strategies of integrated water resource  
management - a case study on Chittagong Hill Tracts (CHTs),  
Bangladesh**



**M.Sc Thesis  
By**

***Shampa Biswas***  
**Mountain Forestry**  
**Universität für Bodenkultur**  
**BOKU-University of Natural Resources and Applied Life Sciences, Vienna**

**Supervisor**  
***Vacik Harald, Ao. Univ.Prof. Dipl.-Ing. Dr.nat.techn***

**Institute of Silviculture, Department of Forest- and Soil Sciences**  
**BOKU-University of Natural Resources and Applied Life Sciences, Vienna**

**Co-Supervisor**  
***Dr. S.M. Sirajul Haque, Professor***  
**Institute of Forestry and Environmental Sciences**  
**University of Chittagong, Bangladesh**

**July 2007**

# **Evaluating management strategies of integrated water resource management - a case study on Chittagong Hill Tracts (CHTs), Bangladesh**



A dissertation submitted to BOKU-University of Natural Resources and Applied Life Sciences, Vienna for the partial fulfilment of "Master of Science in Mountain Forestry"

By

**Shampa Biswas**

Matrikel no: H0540969

Session: Mountain Forestry 2005-2007



**Mountain Forestry**

**Universität für Bodenkultur**

**BOKU-University of Natural Resources and Applied Life Sciences, Vienna**

**July 2007**

# Dedicated to

## *My Beloved Parents,*

Mrs Ratna Rani Biswas & Mr Sontosh Kumar Biswas

## *My respected and honourable supervisor*

Vacik Harald, Ao. Univ.Prof. Dipl.-Ing. Dr. nat. techn

## *Local community in the study area*

Chittagong Hill Tracts Community

## *Working Place*

Institute of Silviculture, Department of Forest- and Soil Sciences-BOKU

and

## *Scholarship Association*

ÖSTERREICHISCHE ORIENT-GESELLSCHAFT HAMMER-  
PURGSTALL(ÖOG)

## **Acknowledgement**

The author is indebted to respectable and sincere Supervisor and Professor **Dr Harald Vacik, ao. Univ. Prof. Dipl. Ing. Dr. MAS (GIS)** for his constant facilitation, encouragement and suggestions from the beginning of the research through arranging good working environment and providing facility of printing and photocopy. In addition, I am really grateful to him for regular and nonstop hard works to collaborate with my research plan, presentations and write up of the thesis. I am happy to extend my wishes to the professors and colleagues of the “H913 Institute of Silviculture” for their friendly and very good administrative support

I convey my honest thanks to Co-Supervisor, Professor and Project Director of Upland Watershed Project in Bangladesh **Dr S. M Sirajul Haque**, in the Institute of Forestry and Environmental Sciences for helping to get lots of research papers and books relevant to my research work as well as he gave me some important contacts. Without his signature, it was not possible for me for making photocopy of the research paper. My honest thanks go to Dr Shafiul Alam, Director, Institute of Forestry and Environmental Sciences, Jalal Uddin Md. Shoaib, Principal Scientific Officer, SRDI, Bangladesh Professors and students of Institute of Forestry and Environmental Sciences, Mr James Gomes, Director of CARITAS for arranging necessary facilities during the research data collection.

I should sincere thanks to Dr. Theresia Laubichler, **ÖSTERREICHISCHE ORIENT-GESELLSCHAFT HAMMER-PURGSTALL** for giving me financial and friendly support and creating homely environment in Austria.

I would like to appreciate the contribution of Professors and colleagues of Mountain forestry.

My heartfelt thanks to “My parents, sister and brother in law” for their love, affection, advice, suggestions, consoling talks overseas and so on.

Shampa Biswas

## **List of Abbreviations**

AHP - Analytic Hierarchy Process  
BCAS- Bangladesh Centre for Advanced Studies  
BCAS-Bangladesh Centre for Advanced Studies  
BFRI-Bangladesh Forest Research Institute  
BHWDB- Bangladesh Haor and Wetland Development Board  
BSB- Bangladesh Sericulture Board  
BSB-Bangladesh Sericulture Board  
BSCIC-Bangladesh small and cottage Industries corporation  
BWDB-Bangladesh Water Development Board  
CARITAS- The Catholic Agency for International Aid and Development  
CEGIS- Center for Environmental and Geographic Information Services  
CHARM- Chittagong Hill Tracts Improved Natural Resource Management  
CHTs- Chittagong Hill Tracts  
CTL-Contour Trash Line  
DPHE - Department of Public Health Engineering  
DRR- Directorate of Relief and Rehabilitation  
DSA-Differentiated Slope Agro-forestry  
DSS - Decision Support System  
EFA- Expanded Food Assistance  
EGIS - Environment and Geographic Information System  
EIA- Environmental Impact Assessment  
FAO- Food and Agriculture Organization  
FCD-Flood Control and Drainage  
FCDI- Flood Control, Drainage and Irrigation  
FFWC-Flood Forecasting and Warning Center  
GIS- Geographic Information System  
GOB-Government of Bangladesh  
GPWM- Guidelines for Participatory Water Management  
GWP-Global Water partnership  
ICDP- International community development programe  
ICDP-CHTs- Integrated Community Development Project-Chittagong Hill Tracts  
ICIMOD-Integrated Centre for Mountain Development  
IFEESCU - Institute of Forestry and Environmental Sciences, University of Chittagong  
IFESCU- Institute of Forestry and Environmental Sciences, Chittagong University  
IWM- Integrated Watershed Management  
IWRM- Integrated Water Resources Management  
JSS- Jana Samhati Samiti  
LGED-Local Government Engineering Department  
MCDM - Multi-Criteria Decision Making  
MDG-Millennium Development Goal  
MoWR- Ministry of Water Resources  
MSL- Mean Sea Level  
NGO-Non Government Organization  
NRM - Natural Resources Management  
NVH-Natural Vegetative Buffer strip

NWMP- National Water Management Plan  
NWP-National Water Policy  
NWRD- National Water Resources Database  
PC - Pairwise Comparison  
PCIV set-Principles, Criteria, Indicators and verifier set  
RS-Remote Sensing  
SALT- Sloping Agro-forestry Landuse Technology  
SRDI-Soil Research Development Institute  
TRIPS- Trade-Related Intellectual Property Rights  
TVA- Tennessee Valley Authority  
VFFP - Village and Farm Forestry Project  
WARPO- Water Resources Planning Organization  
WFP-World Food Programme  
WOCAT- World overview on conservation approaches and Technologies  
WSSD-World Summit on Sustainable Development  
ELCG-Education Local Consultative sub-group  
CBD- Convention of Bio-logical Diversity  
HTF-Hill Tracts Foundation  
IPR-International Property Right  
WASA-Water Supply and Sewerage Authority  
IUCN-International Centre for Nature Conservation

## Abstracts

Integrated Water Resource Management (IWRM) for Chittagong Hill Tracts is one the key future issues in Bangladesh forestry decision making of South Asia to cope with challenges of appropriate policy planning, economic self efficiency, conserving the natural resource base, handle upcoming environmental risks, upgrading standard of the livelihood of people as well as implementing forest management planning. Therefore a combined approach of criteria and indicators (C&I) and Multi-Criteria Analysis (MCA) have been used to formulate a clear and transparent picture of the current situation and to identify a potential and best compromise solution for the sustainable management of mountain watershed of Bangladesh. The IWRM framework was developed in close co-operation with relevant stakeholder groups for a specific watershed area at Bandarban of Chittagong hill tracts. The Multi-Criteria Analysis allowed to formulate a set of 6 principles, 22 criteria, 56 indicators and 192 verifiers to assess the current situation of the selected watershed area. The preferences of key informants have been elicited in order to identify the relevance for the 6 principles policy planning, economic income, ecological maintenance, risk factors, livelihood of people and management planning and their criteria respectively. Within the IWRM framework 6 management strategies have been designed with local experts out of a 46 different activities in order to overcome the current problems in the project area. The management strategies Bio-diversity Conservation Strategy, Flood Control Strategy, Soil and Water quality conservation Strategy, Indigenous Knowledge conservation Strategy, Income generating watershed conservation Strategy and Landscape conservation Strategy have been assessed qualitatively on their potential to improve the current situation according to each verifier of the C&I set. The Analytical Hierarchy Process (AHP) is used for identifying the best management strategy in the context of the pair wise evaluation of each management strategy for all criteria of the C&I set and the different preferences of the stakeholder groups. The Bio-diversity conservation strategy for watershed management is performing best according to overall priorities of IWRM framework among six management alternatives. The identified management strategy has the potential to improve the existing current problems of mountain watershed in Chittagong hill tracts by multilevel institutions through creating awareness about IWRM among local people. As a consequence, major problems of language barriers, ownership right of land, threatened watershed, flash flood, soil erosion and water quality maintenance are expected to be managed. The results of the study indicate that the combined approach of C&I and MCA would be a systematic guideline for CHTs stakeholders to proceed for managing existing environmental problems by effective land management, establishment of eco-village, conservation of bio-diversity hotspot and water quality maintenance. In addition, local people involvement might be ensured for forest conservation by providing high subsidies. Government should start to take initiatives to integrate multilevel institutions to apply and utilize this research result in practical actions in Chittagong hill tracts as this collaborative plan for integrated water resource management has the strength to cover all components like resource planning, people participation, extension services of CHTs watershed management. Annual documentation and reporting might help to understand the existing situation, response, acceptances and consequences of the management strategy.

**Key words:** Integrated Water Resource Management, Criteria & Indicator, Management alternatives, key informants, Multi-Criteria Analysis, Analytical Hierarchy Process

## List of Contents

Dedication.....	II
Acknowledgement.....	III
List of abbreviation.....	IV
Abstract.....	VII
List of Contents.....	VIII
List of Tables.....	X
List of Figures.....	XI
 <b>1 Introduction.....</b>	 <b>1</b>
1.1 Problem definition and justification .....	1
1.2 Objectives of the thesis .....	2
1.3 Structure of the thesis .....	3
 <b>2 Integrated Water Resource Management.....</b>	 <b>4</b>
2.1 International background.....	4
2.2 Integrated Water Resource Management (IWRM) in Bangladesh .....	7
2.3 Use of C&I and MCA in Integrated Water Resource Management .....	12
 <b>3 Materials and Methods.....</b>	 <b>17</b>
3.1 Literature review .....	17
3.2 Background studies .....	17
3.3 Application of the Analytic Hierarchy Process.....	19
3.4 Characterization of research site .....	21
 <b>4 Application of multi-criteria analysis for the CHT.....</b>	 <b>37</b>
4.1 Assessment of current situation in Bandarban, Chittagong Hill Tracts .....	37
4.2 Preferences of criteria and indicators for IWRM .....	71
4.3 Development of management alternatives .....	75
4.4 Assessment of six management strategies .....	89
 <b>5 Comparing the performance of the management strategies.....</b>	 <b>93</b>
5.1 Overall performance of six management strategies for IWRM according to six groups of key informants.....	93
5.2 Performance of six management strategies according to principle 1 “Policy planning” .....	94
5.3 Performance of six management strategies according to principle 2 “Economic Income” .....	94
5.4 Performance of six management strategies according to principle 3 “Ecological Maintenance” .....	95
5.5 Performance of six management strategies according to principle 4 “Risk Factors” .....	96
5.6 Performance of six management strategies according to principle 5 “Livelihood of People” .....	96

5.7 Performance of six management strategies according to principle 6 “Management Planning” .....	97
<b>6 Discussion</b> .....	<b>99</b>
6.1 Sensitivity analysis with the AHP .....	99
6.2 Justification of IWRM strategies in CHT .....	100
6.3 Future direction of IWRM in CHTs .....	103
<b>7 Conclusions</b> .....	<b>104</b>
<b>8 References</b> .....	<b>105</b>
<b>9 Appendix</b> .....	<b>117</b>

## List of Tables

Table – 2.1: Hierarchical classification of Water Uses (Gupta, 2001).....	6
Table-3.1: Areas of CHT hill districts with district-wise population and population densities.....	22
Table-3.2: Land Capability Classes in CHTs (Forestal, 1966, Brammer, 1986) .....	30
Table-3.3: Bandarban District under different slope classes including population and the density of population (ADB, 2001 and Brammer, 1986) .....	30
Table-3.4: Bandarban District Areas (ha) under different slope classes (SRDI Manual).....	30
Table-3.5: Micro-economic (Household) Farming Scenario in Bandarban Hill Districts (ADB, 2001).....	31
Table-3.6: General Information of the research site, Bandarban Sadar (SRDI Manual) .....	31
Table- 3.7: Activities of Integrated Community Development Project-Chittagong Hill Tracts (ICDP-CHTs) by CARITAS .....	35
Table- 3.8: Activities of Horticulture development project, CARITAS, Bandarban.....	35
Table 3.9: Qualitative assessment of six management strategies based on principles and criteria and determination of intensity of influencing verifier by six management strategies .....	89

## List of Figures

Fig- 2.1: Interrelation among key components of IWRM.....	5
Fig – 2.2: Implementing link of the existing MoWR.....	9
Fig – 2.3: Activities of Water Resources Planning Organization (WARPO) in MoWR.....	10
Fig – 2.4: Differences among variables, indicators and indices (Lorenz, 1999).....	13
Fig – 2.5: Monitoring Spiral of reflection, planning, action and observation through C& I .....	14
Fig -2.6: Combination of C&I concept and MCA approach (CIFOR, 1997) .....	16
Fig – 3.1: Hierarchy of IWRM Framework of principles and criteria cascading from the decision objective or goal. ....	20
Fig – 3.2: Schematic ideal integrated production system for CHT hill slopes (ADB, 2001) .....	27
Fig 3.3: The map showing mountainous area of Bangladesh indicating research site, Bandarban Sadar thana (FD, 2007) .....	29
Fig - 3.4: Soil Conservation and Watershed Management Centre, Talukdarpara community” and “Reichathalipara community” in Bandarban Sadar (SRDI Map, 1987) .....	32
Fig - 3.5: Small catchment area.....	33
Fig - 3.7: PhD research programme .....	33
Fig – 4.1: Comparing the key informant’s preferences at principal level for IWRM Framework from face to face preference elicitation.....	71
Fig – 4.2: Comparing the key informant’s preferences at criteria level for Policy planning of IWRM Framework from face to face preference elicitation .....	72
Fig – 4.3: Comparing the key informant’s preferences at criteria level for Economic Income of IWRM Framework from face to face preference elicitation .....	72
Fig – 4.4: Comparing the key informant’s preferences at criteria level for Ecological Maintenance of IWRM Framework from face to face preference elicitation.....	73
Fig - 4.5: Comparing the key informant’s preferences at criteria level for Risk Factors of IWRM Framework from face to face preference elicitation .....	73
Fig – 4.6: Comparing the key informant’s preferences at criteria level for livelihood of.....	74
Fig – 4.7: Comparing the key informant’s preferences at criteria level for Management Planning of IWRM Framework from face to face preference elicitation.....	74

Fig – 4.8: Number of verifier influenced by six management strategies on each principles of IWRM Framework in CHTs through determining each influenced verifier on each criteria of PCIV set. ....	91
Fig – 4.9: Comparing overall performance of six management strategies for IWRM framework through preferences of six key informants after pairwise comparison .....	93
Fig – 4.10: Comparing Performance of six management strategies for principle 1 “Policy planning” according to seven groups of key informants at principal level .....	94
Fig – 4.11: Comparing Performance of six management strategies for principle 2 “Economic Income” according to seven groups of key informants at principal level .....	95
Fig – 4.12: Comparing Performance of six management strategies for principle 3 “Ecological Maintenance” according to seven groups of key informants at principal level .....	95
Fig – 4.13: Comparing Performance of six management strategies for principle 4 “Risk Factors” according to seven groups of key informants at principal level .....	96
Fig – 4.14: Comparing Performance of six management strategies for 5 “Livelihood of People” according to seven groups of key informants at principal level .....	97
Fig – 4.15: Comparing Performance of six management strategies for principle 6 “Management Planning” according to seven groups of key informants at principal level .....	97
Fig 4.16: Performance of six management strategies at principle level according to sensitivity analysis by AHP .....	99

## ***1 Introduction***

### **1.1 Problem definition and justification**

Mountain Environment acts as weather makers for larger parts of the world. It is important repositories for global diversity and right locations for spiritual and cultural recreation, especially in tropical areas. Mountains and highlands cover about a quarter of the Earth's land surface and are home to 10% of the world's people. Another 40% live in adjacent lower watershed areas; thus more than half of the global population is directly or indirectly at the mercy of mountain assets and services, the foremost being water for drinking and home use, irrigation, hydro power, industry and transportation. Three billion people, more than half of the world's population relies on mountains for water for drinking irrigation, industry and security (Messerli, 2001; Salahi, 2002).

The assets of mountainous region in Bangladesh are resources of invaluable fresh water, biodiversity, hydro-electric power, indigenous knowledge, cultural heritage and tourism. Bangladesh watershed with an area of 14.4 million ha and 135 millions people is situated between the northern side of Bay of Bengal and the southern foothills of Himalayans. Over 80% of the country is low-lying, waterlogged and flooded at least part of the year. Much of the area does not exceed 40m ASL, making the landscape the single largest flood basin in South Asia (IUCN, 2004). This watershed was formed from sediments by the three major rivers: the Ganges, the Brahmaputra and the Meghna traveled over the upland countries Bhutan, China, India and Nepal and their distributaries. The country constitutes three physiographic units: Tertiary hills covering 12%, Pleistocene terrace 8%, and Recent plains 80% of the land area. River system in the hilly region is originated mostly within the country and constitutes the upland watershed (Banglapedia, 2007).

Previously population pressure was confined only to the lowland watershed and at present population density is increasing in the hilly region at an alarming rate because of migration of people from plain land. Conversion of forest to agriculture through clearing, burning and shifting cultivation; is the main land use at present due to over population in this region. Newly constructed road to inaccessible hilly areas makes the deforestation rate rapid and widespread. The hills have been converting into barren and deteriorated sites as a result of cutting and lopping of trees, excessive grazing and clearing of land for shifting cultivation, unregulated felling, clear-felling, accidental and incendiary fires, and mismanagement. In spite of environmental, economic, rural and socio-cultural importance, most mountain and upland areas have been excluded from development over the last 50 years. At the same time, their natural resource base has been depleted. Poverty and environmental degradation are now widespread in upland rural communities. Some of the most important factors contributing to this situation include: (i) fragile mountain watershed ecosystem, (ii) population growth, (iii) shortage of arable land and low agricultural yields, (iv) disadvantaged market conditions, (v) inadequate job opportunities, (vi) lack of infrastructure and services, (vii) non-co-operating attitude from political leaders, and (viii) existence of top-down conservation policies (BARC, 1999; Farid, *et. al.* 1992; Shahid, 1994; IUCN, 1991; Thapa and Rasul, 2006; Gafur, 2001; DANIDA, 2000; Knudsen & Khan, 2002).

The concept of “Watershed Management” is very new in Bangladesh. A *watershed* means, the entire catchment area, both land and water, drained by a watercourse and its tributaries. A sub watershed means, the catchment area drained by an individual tributary to the main watercourse. The meaning of *Watershed Management* is a process of managing human activities in an area defined by watershed boundaries to protect, rehabilitate land and water, and associated aquatic and terrestrial resources, while recognizing the benefits of orderly growth and development. Problem identification, data gathering, analysis and planning, implementation and monitoring; are most important phases for Watershed management. Main benefit from watershed management is to extract the environmental, social and economic well being of the area on a sustainable basis. So, watershed management is an approach which assists land and water use decision makers (Morris, 1976; PMC, 1997).

The practice of watershed management has evolved over the decades as it possesses the capability to integrate and address a broader range of resource and environmental protection issues in a comprehensive way. It also evaluates the important linkages between land and water, between surface and ground water and between water quality and water quantity. During 1990, the objectives were evaluating watershed management to minimize effects of developments. Later it was converted to maintain and enhance natural system. Watershed management initiatives include integration using the boundaries of sub-watershed Eco-system based approach to water resource based sub land use. Chittagong hill tracts watershed has few limitations for crop production where 3 to 5% land can be used for crop, 20% slopes are suitable for horticulture and the rest 75% land are vulnerable hill slopes. The major land uses are shifting cultivation, horticulture, tea, rubber, yam, ginger on different parts of the hill slope without considering soil loss. As a result, disturbed upland watershed have been seriously affecting the low land watershed through environmental deterioration (Beattie, 1969; Khan and Haque, 2003; Shoaib, 1997).

Watershed management in Bangladesh is necessary for sustainable protection of natural resources and environmental health, to recognize the hydrologic or water cycle as the pathway that integrates physical, chemical and biological processes, to adopt efficient, cost-effective development and land use patterns in planning for community growth. The idea for working on degraded watershed comes from my previous working experience in Chittagong hill tracts as well as M.Sc course of Watershed management in the Institute of Forestry and Environmental Sciences, Bangladesh. Afterwards, the idea of using Multi-criteria Tools comes from the “Multi-criteria Decision Making” courses of Mountain Forestry Course and address decision and systematic approach which helped to handle problems explicitly.

## **1.2 Objectives of the thesis**

The aim of this research study is to identify a potential and best compromise solution for sustainable management of Mountain Watersheds in the Chittagong Hill Tracts (CHTs)

The specific objectives are:

1. To identify the main objectives for the sustainable management of a Mountain Watershed in the Chittagong Hill Tracts
2. to identify relevant, sufficient and measurable criteria and indicator or sub-criteria to further decompose the objectives and justify them

3. to identify the preferences for the objectives and the criteria with local experts using a MCA method
4. to identify alternative management strategies with the help of local experts and characterize them according to the verifiers (quantitative or qualitative)
5. to evaluate these management strategies according to the objectives using a MCA method
6. to identify the sensitivity of the results according to a change of preferences

### **1.3 Structure of the thesis**

1. Introduction reflects the importance of the research study through defining problems in Chittagong Hill Tracts of Bangladesh, specifying objectives and structure of the thesis.
2. Integrated water resource management gives an impression about concepts of international and national background of IWRM, evaluating IWRM in CHTs through building systematic C & I hierarchy and using C & I and MCA approach.
3. Materials and methods tries to inform, how literature review is done and from which sources are used; how research sites are selected, how preliminary CIV (Criteria, Indicator and Verifier) set and evaluation preference form are developed for preference elicitation of key informants; how field visits in Bangladesh is done through preference elicitation with the help of Evaluation Preference Form; Background, history and purpose of the research site; how application of AHP helps for developing IWRM framework in Chittagong Hill Tract and how pairwise comparison identify the best and compromise alternatives for sustainable management of a Mountain Watershed in the Chittagong Hill Tracts (CHTs).
4. Application of multi-criteria analysis for the CHTs entails, how multi-criteria tools are applied for assessing current situations, developing and assessing six management strategies based on the result of the current situation
5. Results are the compiled part in combination with describing the importance of criteria and indicators for IWRM, and comparing the performance of the management strategies
6. Discussions investigate the sensitivity of the alternatives to change the priorities of the criteria for achieving the goal, problem solution within IWRM framework and future possibility for developing DSS
7. Conclusions focus the main message of the importance of doing this research, achievement, probable future directives and solution for sustainable integrated water resource management through watershed management in Chittagong Hill Tracts of Bangladesh.

## 2 *Integrated Water Resource Management*

2.1

### **International background**

The modern concept of Integrated Water Resource Management (IWRM) is defined as a process which promotes the co-ordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP, 2000). The term “Integrated Water Resource Management” derived first with an example of the establishment of the Tennessee Valley Authority (TVA) in 1933, from the USA which integrated the functions of navigation, flood control and power production, while addressing the issues of erosion control, recreation, public health and welfare. The Tennessee Valley Authority (TVA) effort contained many elements of today’s perception of comprehensive planning for natural resource utilization combined with economic, social and even environmental objectives. The UN and other international organizations have played a significant role in the development of the concept of Integrated Water Resource Management (Creighton 1999 and Mitchell, 1990).

The roots of IWRM can be traced back to the International Conference Mar del Plata, where the need for co-ordination in the water sector was stressed, and the Brundtland Commission report, which was the first call for development that would not compromise the needs of future generations. It’s basic principles were largely established by 1992, the year in which the Dublin Guiding Principles were formulated and the United Nations Conference on Environment and Development was held in Rio de Janeiro (FAO, 2004).

Many countries are experiencing water related problems like drought, flooding, ground water overdraft, water-borne diseases, land and water borne diseases, land and water degradation, on going damage to ecosystems, chronic poverty in rural areas and escalating conflicts over water. An IWRM approach provides an opportunity to attack these problems more effectively-identifying root causes and solutions (GWP, 2004)

The core of IWRM strategy should be the definition of the areas for actions necessary to address a country’s water challenges in such ways that are economically efficient, socially equitable and environmentally sustainable. It addresses water governance (management) together with water resources infrastructure (development), water service (use) in an integrated way (GWP, 2006a). A strong monitoring and evaluating system helps not only to meet the fulfillment of the main objectives of fostering positive change adopting with certain needs and conditions, but also evaluate the progress towards the achievement of IWRM strategy and plans (GWP, 2006b).

EU’s Water Framework Directives is a new tool for Integrated Water Resource Management through fulfillment of environmental objectives that is to create good status for all waters by 2015. Analysis of pressures, impacts and economic analysis of water status, river basin management plan with programme of measures including existing directives (main instrument for planning and reporting); water pricing policies operational 2010 (instrument supporting environmental objectives) and public participation in a practical action (Fig-2.1)

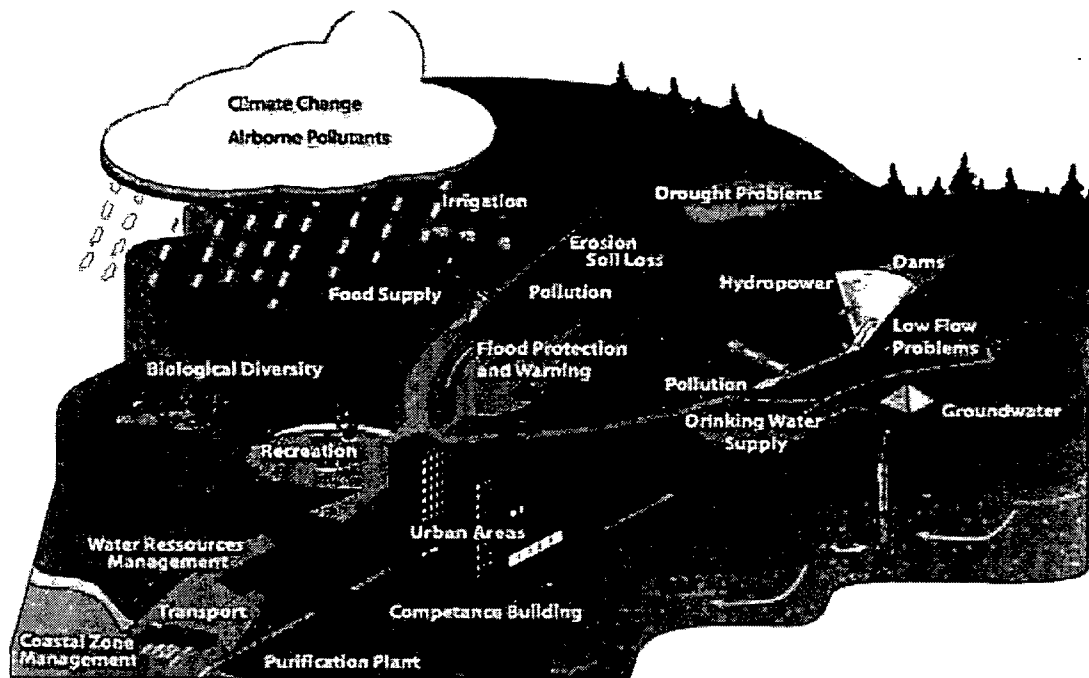


Fig- 2.1: Interrelation among key components of IWRM

The need to improve water efficiency was recognized in 2002, and focused as a new movement by the World Summit on Sustainable Development (WSSD). According to article 26 of the WSSD Plan of implementation, an action sets target for the preparation of “IWRM and water efficiency plans” by 2005, makes reference to water efficiency in two different ways: Art. 26 (a) proposes to introduce measures to improve the *efficiency of water infrastructure* to reduce losses and increase recycling of water”. Art. 26 (c) says to improve the efficient use of water resources and *promote their allocation* among competing uses in a way that gives priority to the satisfaction of basic human needs and balances the requirements of preserving or restoring ecosystems and their functions, in particular in fragile environments, with human domestic, industrial and agriculture needs, including safeguarding drinking water quality” As Article 26 highlights, improving efficiency has multiple aspects that considers wider social issues and values as well as physical and technical concerns. It entails finding ways to maximize the value of water use and allocate decisions within and between sectors for sustainable social and economic development (WSSD, 2002).

Global Water Partnership (GWP) is formally established in 1996. It is an international network that is open to all organizations involving water resources management in developed and developing country government institutions, agencies of the United Nations, bi- and multilateral development banks, professional associations, research institutions, non-governmental organizations and the private sector (GWP, 2000).

Table – 2.1: Hierarchical classification of Water Uses (Gupta, 2001)

Water uses			Objectives	Effects
Municipal and industrial use	Municipal uses (O)	Domestic	Use for cooking, washing, watering lawns, and air conditioning	Remove water from system, adds pollution to river and underground aquifer
		Public	Use in public facilities and for fire fighting	
		Commercial	Use in shopping centers, hotels, and laundries	
		Small industrial uses not having a separate water supply system	Use for industrial production	
		Conveyance losses in the distribution system	—	
	Industrial uses (O)		Use for large water-using industries such as steel, paper, chemicals, textiles and petroleum refining	
	Waste dilution (I)		Serve as the source for self-purification of the stream	
Demand for Agriculture (O)	Irrigation		Use for raising crops	Remove water from system, adds sediment, nutrients and agricultural chemicals to river and underground aquifer
	Factory farm uses		Use for livestock	
	Conveyance losses and waste		—	
Demand for hydropower (I)	Hydropower generation		Produce hydropower	Helps regulate river flow
Demand for navigation (I)	River regulation		Water release from upstream reservoirs to raise water depth	Keeps water in river
	Lock-and-dam		Increase water depth for navigation through ship locks and dams	
	Artificial canalization		Use for artificially constructed channels with a number of ship locks	
Other demands	Flood storage (I)		Control floods	Provide downstream flood protection
	Recreation (I)		Provide a place for swimming, fishing and other recreation activities	Keeps water in river
	Water export (O)		Large diversion and export for commercial purposes	Remove water from system
	Ecological uses (I & O)		Conservation of scarce aqua lives, use for forestry, filling wetlands, etc.	Keeps water in river, or remove water from system

The Global Water Partnership is one of many players concerned with trying to achieve water security and as creator of the framework for water resource management in a practical way. Since its inception, GWP has built up a network of regional partnerships in America, Europe, China, Mediterranean, Pacific, America, Asia and Africa. These regional partnerships bring various sectors and interest groups together to identify and discuss their common water problems and to develop action plans based on IWRM (Fig - 2.1). Primary actions are concentrated on water, agriculture, drought and gender equality". Secondary actions are disaster management and vulnerability, biodiversity, sustainable development in a globalizing world, poverty eradication, marine resources, desertification, sustainable development for Africa, Rural development, Institutional framework for sustainable development, and land (GWP, 2002).

Global Water Partnership supports countries for sustainable management of their water resources to establish the principles of sustainable water resources management at local, national, regional or river-basin level that follows principles of sustainable water resources management. The overall development goal is to achieve global water security as a contribution by eliminating poverty, improving well-being and protecting natural resources. Today, this comprehensive partnership actively identifies critical knowledge requirements at global, regional and national levels that, helps design programs for meeting these needs, and serves as a mechanism for alliance building and information exchange on integrated water resources management. It is an international networking organization that is dedicated to the application of integrated water resources management as laid down in the Dublin principles and can play a catalytic role in bringing actors together to work on strategic IWRM issues. It has an important function to fill in the follow up to its work on the Framework for taking comprehensive action for multiple benefits (Table – 2.1) of water uses and objectives (e.g. water demand for municipal and industrial uses, agriculture, hydro-power, and navigation and so on) (Gupta, 2001).

## 2.2 Integrated Water Resource Management (IWRM) in Bangladesh

Bangladesh is a lower riparian country located within flood plains of three great rivers, the Ganges, the Brahmaputra and the Meghna. There are many tributaries and distributaries of these rivers and in total 57 rivers pass through the country. These rivers drain a total area of 1.72 million square kilometers in India, China, Nepal, Bhutan and Bangladesh. Over 90 percent of the catchment area for the rivers in Bangladesh lies outside Bangladesh. As a result, huge inflows of water enter the country, over which Bangladesh has no control. The lack of controls is a critical problem because Bangladesh has an agrarian economy dependent on water, and Bangladesh has either too much or too little water at different times within a year. The average surface water flow in peak-wet season (August) is nearly 112 billion cubic meters and in the dry season (February) is about 3.7 billion cubic meters. During the wet season (June – September), massive river flows in a flat delta topography (which severely limits effective drainages) – further accentuated by high rainfall occurring only in a limited four months period – makes flooding a recurring phenomenon (ADB, 2003).

Whether it is drinking or sanitation, irrigating crops, manufacturing or India's proposed river-linking project, there are multiple demands and perceived threats on Bangladesh's water resources. In addition, the floods during the monsoon season and the scarcity of water during the dry season cause extreme misery and hardship to millions of people. There are many challenges to develop an integrated national and transboundary approach towards the managing of water resources in Bangladesh. Bangladesh's Water Development Board (BWDB), for example, estimates that more than 170 of Bangladesh's 230 large and medium rivers are suffering from pollution and poor water management. The Government of Bangladesh also predicts that India plans to divert water from major rivers, the Ganges and Brahmaputra that threatens the livelihoods of more than 100 million people downstream in Bangladesh. The country's position as the lowest riparian country, has little control over the huge cross-boundary flows of water. And, despite the Government embarking on a series of water sector reforms including the adoption of the National Water Policy (NWP) in 1999, and preparation of the 25-year National Water Management Plan (NWMP) in 2001, areas of weakness remain particularly at an institutional level. These include a lack of formal arrangements for water allocation, fragmentation of water

issues and responsibilities across several ministries, lack of capacity especially at local government levels, and the limited involvement of local communities. The growing need is to adopt a basin-wide approach to the management of the waters of the Ganges, Brahmaputra, and Meghna Rivers with institutional strengthening by creating the potential role of water sector apex bodies. The importance of water decision-making at the district and local level is also believed how to incorporate IWRM into water resource planning; and the sharing of transboundary river water (ADB, 2005)

### 2.2.1 Key issues of Integrated Water Resource Management (IWRM) in Bangladesh

The total land area of Bangladesh is about 14.4 million ha of which 0.67 million ha hill forest constituting 4.54% of total land area of the country. The hills are the major sources of natural forests comprising more than 40% forest of the country. The Chittagong Hill Tracts have the second largest reserved forest (322, 331 ha) of the country. The region has much smaller (1%) protected forests and there is the residual category of forests known as Unclassed State Forests, which constitute about 75% of the Chittagong Hill Tracts (SHED, 1998).

Both flora and fauna in Chittagong hill tracts are threatened by the loss of habitat resulting from increasing human populations, and unwise bio-resource utilization. Increasing demand for timber and fuel-wood, illegal encroachment and shifting cultivation (*Jhum*) in the hilly districts, might be the aggravating factors in the annual rate of deforestation and degradation. The unplanned, rapid urbanization and industrialization are leading to waste and pollution problems that affect natural ecosystems. As the land and water-based ecosystems are environmentally compromised the flora and fauna populations are being seriously affected (ADB, 2001).

The most critical aspects of Integrated Water Resource Management (IWRM) are alternating flood and water scarcity during the wet and dry seasons due to ever-expanding water needs of a growing economy and population, massive river sedimentation and bank erosion. There is also a growing need for providing total water quality assessment, management, and maintenance of the eco-system. Furthermore, there is an urgency to satisfy multi-sector water needs with limited resources, promote efficient and socially responsible water use, delineate public and private responsibilities, and decentralize state activities where appropriate. All of these have to be accomplished under severe constraints, such as the lack of control over rivers originating outside the country's borders, the difficulty of managing the deltaic plain, and the virtual absence of unsettled land for building water structures.

According to 3rd World Water Forum, Japan, the key Issues of IWRM in Bangladesh can be described as follows:

1. Addressing Flood, Drought and River-Bank Erosion,
2. Mitigation of Cyclone damages,
3. Trans-boundary Water Sharing, depletion of surface and ground water, Salinity intrusion,
4. Recent drive for interlinking of common rivers on the upstream, consequent disasters,

5. Exchange of Hydro-meteorological data among co-riparians,
6. Basin-wide Water Resources Management,
7. Supply of Safe Drinking Water and Sanitation Facilities,
8. Mitigation of Arsenic Contamination,
9. Promotion of community participation,
10. Provision of self-sufficiency in food production and poverty reduction,
11. Climate change, subsequent submergence of vast land, extreme events (JWF, 2007).

According to the Ministry of Water Resources (MoWR), Bangladesh is committed to Millennium Development Goals to develop self-help strategy for development of water resources through international cooperation and assistance needed for IWRM by for initiating discussion on water issues through forming Japan-Bangladesh Cooperation Group. For example, protection of World Heritage and Ramsar Sites, reducing rural and urban poverty, supplying safe drinking water for all by 2025, participatory water management, integrated coastal zone management, protecting major cities from floods and preparing adaptation for climate change, translation of projects and programme of NWMP in the form of Annual Development Programme, adoption of participatory water management, initiation of supplying country-wide drinking water, development of numerical models with remote sensing and GIS technologies for improving disaster management services , control of river-water pollution and studies for arsenic removal and provision for alternate sources.

## 2.2.2 The Ministry of Water Resources of Bangladesh

The Ministry of Water Resources was newly named instead of the Ministry of Irrigation, Water Development and Flood Control is the apex body of the Government of the People's Republic of Bangladesh for development and management of the whole water resources of the country.

Apex body of the Ministry of Water Resources in Bangladesh

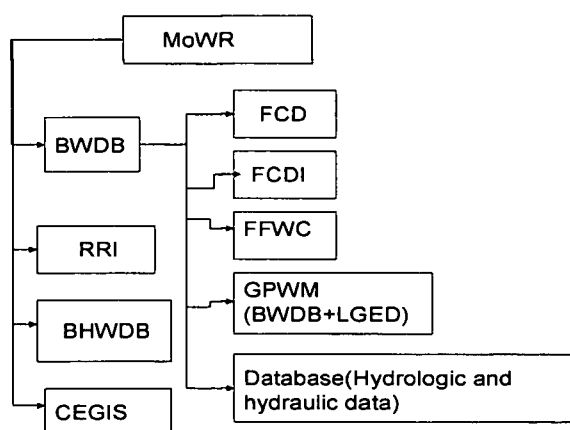


Fig – 2.2: Implementing link of the existing MoWR

The Ministry, through its implementing arm -the Bangladesh Water Development Board (BWDB), implements the Flood Control and Drainage (FCD) / Flood Control, Drainage and Irrigation (FCDI) (FCDI) and other development projects. It also collects, processes, stores and disseminates hydrological and hydraulic data and information through BWDB. It provides flood forecasting and warning information through Flood Forecasting and Warning Center (FFWC) of BWDB. The Ministry prepared the Guidelines for Participatory Water Management (GPWM) with the help of BWDB and LGED (Fig – 2.2).

The Ministry through its macro-planning arm –the Water Resources Planning Organization (WARPO) prepared National Water Policy, the Coastal Zone Policy, National Water Resources Database (NWRD), National Water Management Plan (NWMP) and Integrated Coastal Resources Database (ICRD). Data can be collected from WARPO for nominal charges (Fig – 2.3). The Ministry has also research and coordinating institutions such as River Research Institute (RRI) responsible for physical and mathematical water modeling; Bangladesh Haor and Wetland Development Board (BHWDB) for the development of haors and wetlands; Institute of Water Modeling for mathematical water modeling; and Center for Environmental and Geographic Information Services (CEGIS) for integrated environmental analysis using GIS, remote sensing (RS), database and IT (Fig – 2.3).

The Joint Rivers Commission, Bangladesh acts as the secretariat of the Ministry for dealing with the sharing and management of the waters of the trans-boundary rivers.

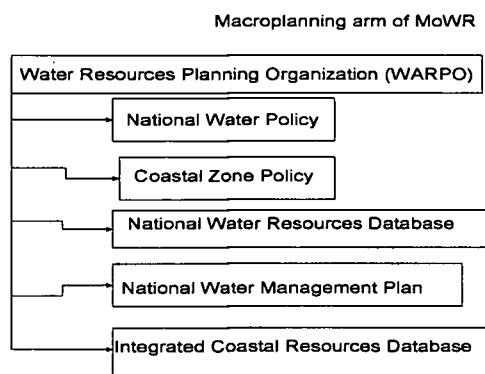


Fig – 2.3: Activities of Water Resources Planning Organization (WARPO) in MoWR

Other principal activities of the Ministry include expansion of irrigated areas, water conservation, surface and groundwater use, estuary control, anti-salinity measures and anti-desertification activities, re-excavation of canals and rehabilitation of embankments, international cooperation, liaison with the international organizations, processing matters relating to treaties and agreements with other countries and world bodies in the field of water development and management. The Ministry of Water Resources has three wings namely Development Wing; Planning Wing and Administrative Wing.

According to the National Water Policy(1999), the Ministry is responsible for formulation of a framework for institutional reforms to guide all water sector related activities and will:

- exercise water allocation power in identified scarcity zones on the basis of specified priorities and determine the priority for allocating water during critical periods;
- sustain shallow groundwater aquifers, regulating the extraction of water in identified scarcity zones with full public knowledge;
- prepare specific drought monitoring and contingency plans for each region experiencing recurrent seasonal shortage of water etc;
- empower local government or any other body, to allocate water in scarcity zones during periods of severe drought, monitor the water regimes and enforce the regulations etc;
- confer water rights on private and community bodies to provide secure, defensible and enforceable rights to ground/surface water etc;
- ensure the minimum requirement of stream-flows for maintaining the conveyance of the channel.

About 10,000 hectare of land is lost in the river every year. 100,000 hectare of land is reclaimed till today by constructing cross-dams and more 60,000 hectares would be possible to reclaim in the same manner. River and canal digging program is being implemented all over the country and the integrated haor and wetland development program has been undertaken.

The concept of integrated water resources management (IWRM) has suggested that countries should prepare national water plan to translate guiding principles for action at river basin and to bring IWRM concept into reality at the national, and the sub-national and local levels. According to IWRM initiatives in Bangladesh, describes concepts of water resources systems, water sector assessment, water allocation among different stakeholders and users, function and values of water resources, water policy and strategy and water legislation and standards, institutional framework and capacity building for implementing IWRM process in Bangladesh and later it has been described river basin management as a subset of IWRM. River basin planning and management may broadly be conceived as an attempt to identify the best possible utilization of the available water resources for certain soil, land, agricultural, engineering and social constraints. Due to multitude of existing conflicts over the utilization of a particular source between individual schemes and the interdependency between water, soil and land use, river basin management through water resources development, is indeed a complex task (Khan, 2004).

The National Water Policy sets new paradigms for the water sector. It include decentralized water management, cost sharing and cost recovery; private sector participation, community participation, nontraditional financing modalities, regulation separated from supply and new rights, obligations and accountability. These will have considerable bearing on the existing institutions and the way in which they manage their affairs and inter-act with others. A new National Water Code is being prepared that would align with Policy requirements (National Water Policy, 1999).

## 2.3 Use of C&I and MCA in Integrated Water Resource Management

Integrated water resources management (IWRM) requires trade-offs between society, economy and the environment. Therefore, information is needed on cause-effect relationships and socioeconomic and environmental effects of policy measures (Hettelingh. *et. al.*, 1998; Hammonds, *et. al.*, 1995; Swart and Bakkes, 1995; Bakkes *et. al.*, 1994). Severe water shortage affects 400 million people today and will affect 4 billion people by 2050 by recently published documents from the UN Environmental Program. For countries that are facing potable water shortage problems, IWRM is a possible approach to overcome these limitations. It allows to recognize the multidimensional character according to time, space, discipline (science or technology) and stakeholders (regulators or users or providers or neighbors) and the necessity to address, embrace and relate these dimensions holistically (Thomas and Durham, 2003). IWRM makes the general concept of sustainable development operational for the management of fresh water resources. IWRM adopts a holistic approach, which implies that information is needed on the state of economy, society and their mutual relationships. It also invokes the need for greater participation, which means that there must be tools for effective communication between different groups of policy makers, e.g., policy makers, the public and scientists (NRET, 2001).

In this context the application of multi criteria analysis (MCA) and the use of criteria and indicators (C&I) is widespread and growing (Bailey *et al.* 2000; French and Geldermann, 2005; Shackley and McLachlan, 2006; Fisher, 2006). The concept of an integrated assessment by the use C&I was derived from common understanding of many organizations and initiatives for sustainable forest management from the Montreal process (1994) and the Santiago declaration (1995) subsequently. C&I can be a valuable tool for mutual learning between community and partners, sharing local, scientific and other external knowledge and guiding actions towards sustainable forest management in a participatory and collaborative way. Multi-Criteria Analysis is a process applied for complex multi-criteria problems that include qualitative and/or quantitative aspects of the problem in the decision-making process. It is an appropriate tool for addressing some challenges involved in C & I assessment (Prabhu *et al.* 1999, 1998; CIFOR, 1997). There is a pressing need to better understand how MCA impacts, and potentially improves, environmental decision making processes. In this context multi-criteria decision making (MCDM) techniques have been integrated with Decision support system for explicit or implicit explanation of multi-objective management and helps decision makers to model trade-offs between different key informant's conflicting values, interests and objectives (Ananda and Herath, 2003; Prato, 1999; Fernandes, *et. al.*, 1999; Vacik, 2005; Vacik and Lexer, 2001).

### 2.3.1 Key elements of C&I assessment

An entire C & I framework consists of objectives, principles, criteria, indicators and verifiers. An effective code of practice for CIV assessment needs to include a hierarchy of different elements, (according to Prabhu *et al.* 1999; Lammerts and Blom, 1997; NRET, 2001): objectives (Basic aims of code of practice), principles (Fundamental ideals which help to elaborate the meaning of objectives), criteria (Conditions that need to be met in order to adhere to principle ), indicators (Measurable states which allow assessment of whether or not associated criteria are being met)

and verifiers (Information or observations that will be used to demonstrate that the required state is being realized).

A number of institutions have attempted to develop different sets of C & I under the leadership and guidance provided by the Forest Stewardship Council (FSC 1994). Most of these sets of C&I, while they have been developed somewhat independently, are nonetheless quite similar and generally follow a common framework. In particular, most of them follow the hierarchical framework organized around the three general elements: principles, criteria and indicators (ITTO 1992, SCS 1994, SGS 1994).

According to Lorenz (1999), variables, indicators and indices are different stages of information collection. Indicators take variables and condense them into manageable information sets, which are then further condensed by indices. These can then be translated into policy-oriented information (Fig –2.4).

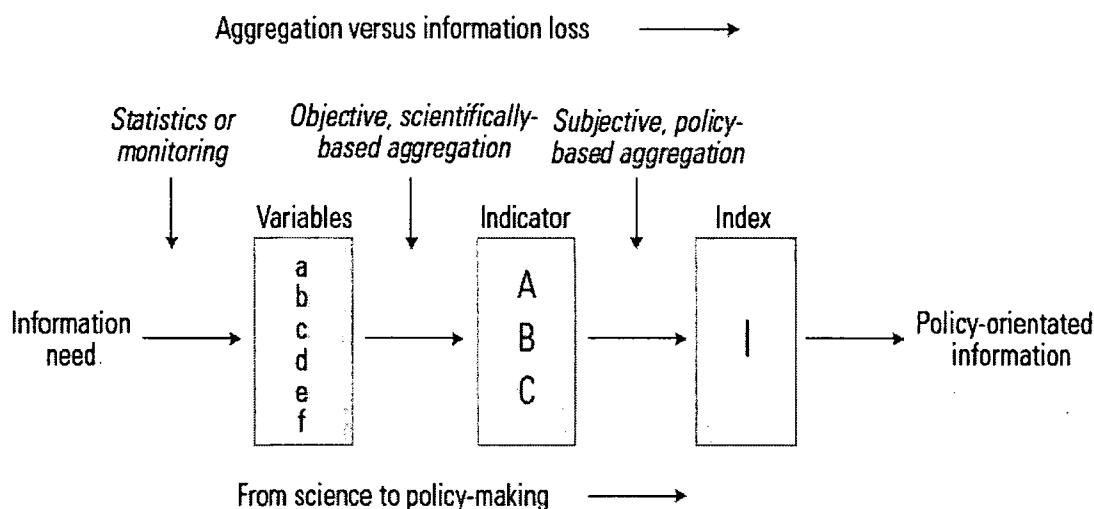


Fig – 2.4: Differences among variables, indicators and indices (Lorenz, 1999).

In this context a C & I framework is a means of linking wisdom, knowledge, information and data in a comprehensive, coherent and consistent manner that is capable of verification (CIFOR, 1997; Prabhu, *et. al.* 1999).

The formation of criteria, indicators and verifiers allows to build up a clear, transparent and acceptable information database on existing situation about the interest of people, society, economy, and environment and environmental policies according to site-specific demand.

For example Criteria and indicators were endorsed by the 1994 United Nations “Montreal Process” and subsequent 1995 “Santiago Declaration”, along with a number of other organizations and initiatives to provide a common understanding of what is meant by sustainable forest management and to frame the monitoring process (Prabhu *et al.* 1999, 1998). Indicators should be developed through participatory processes, including stakeholders from different levels and around the world. Indicators have to meet a whole set of criteria, where both condition and

types of indicators can be developed in the ways in which they may be constructed and used' (NRET, 2001). Because the same indicator has to satisfy often conflicting but equally important social, political, financial and scientific objectives, deriving indicators becomes an objective maximization exercise constrained by available time, resources and partnership arrangements (CIFOR, 1997; Prabhu, *et. al.* 1999).

The need for scientific validity, on the other hand, requires that indicators must simplify without distorting the underlying patterns or losing the vital connections and interdependencies that govern the real world. In addition, indicators are powerful tools for collecting, processing and reporting information and interests within a system in terms evaluating a situation; as a communication instruments to improve clarity on complex items; as forecasting tools for picturing future trends, as a means for the collection of information and interests; as a means for checks of effectiveness of programs and measures (Prabhu *et al.* 1999; Lammerts and Blom, 1997; NRET, 2001; Vacik, *et. al.*, 2006).

According to Beasley (2001), local level indicators (site specific indicators) can be used in scenario modeling to predict whether proposed management plans, strategies and practices achieve management objectives.

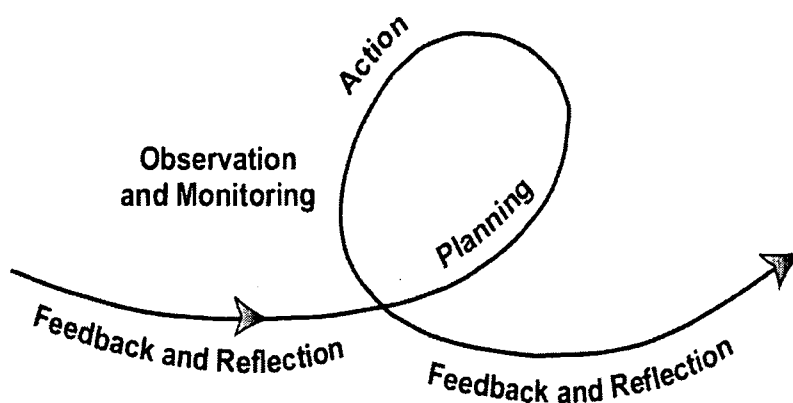


Fig – 2.5: Monitoring Spiral of reflection, planning, action and observation through C& I (Beasley, 2001).

Reporting of indicators is a means of demonstrating successful and unsuccessful management strategies and policies at local to international scale. Moreover, indicators help to define and describe the key elements of standard planning in future through assessment of the effectiveness by utilizing feedback and reflection (Fig – 2.5).

According to (CIFOR, 1997), the intended field testing of the criteria, indicators and verifiers provide a strong indication to their utility and lead to suggestions for revision and replacement of indicators and verifiers. It is the potential, pragmatic and comprehensive way of developing new technologies and solutions to problems in cheap, quicker and more reliable verifiers.

### 2.3.2 Using a C&I and MCA in evaluating management strategies

Both MCA techniques and C&I are capable to communicate and explain the situation in conflicting decision stage (CIFOR, 1999). In addition, it assists to separate the decision elements and track down the ideal decision-making process, suited to communicate the basis of all decisions. Such tools are desirable to achieve knowledgeable, consistent and rational decisions. A combined approach of MCA and C&I assessment, has the strong capability to formulate both qualitative and quantitative information (CIFOR, 1997) by analyzing complex problems like problems of flood, drought and river-bank erosion, mitigation of cyclone damages, trans-boundary water sharing, depletion of surface and ground water, salinity intrusion, community participation, self-sufficiency in food production and poverty reduction. Direct participation of multiple experts, interest groups and stakeholders are possible to incorporate to make the management acceptable (CIFOR, 1997; Prabhu, *et. al.*, 1999).

To support this approach an initial set of C & I is assessed through ranking or rating processes, (by pairwise comparisons, scoring or relative weighting) according to the perceptions and preferences of interest groups (Fig -2.6). For multi criteria analysis the Analytical Hierarchy Process (AHP) is often used as a tool that helps to organize decision problems in a transparent and structured way and derive preferences for sets of criteria and indicators (Steiguer, *et. al.*, 2003). The real strength of AHP, though, is that it treats the decisions as a system which is difficult for many decision makers to do. Bounded rationality and limited cognitive processes make it nearly impossible for the decision makers to adequately consider all of the situations involved in a complex screening decision (Hanfield, *et. al.* 2002). AHP has been used in many studies with MCA that can provide a sound basis for eliciting weights of stakeholder's preferences (Qureshi and Harrison, 2003). AHP assists the implementation of Integrated Watershed management for suitable group decision making (Steiguer, *et. al.*, 2003). In addition, AHP is by nature a multi-stakeholder and multi-criteria analysis to decision support that is suitable to examine trade-off between landholders and other interested parties in a management planning. It can be a powerful decision-support tool within a multi-criteria analysis framework (Quershi and Harrison, 2003; Mendoza 1997a,b; Saaty, 1995; Golden, *et. al.*, 1989 and Vargas and Zahedi, 1993).

The interactive development of C & I and the application of multi-criteria analysis helps to select the most cost effective, ecologically effective management strategy and negotiate for Integrated Water Resource Management. It also assist decision maker and policy makers to increase focusing on sustainable development and make a common structured plan for easy assessment, approval and monitoring for multi-attribute use of IWRM. Furthermore, Integrated Watershed Management (IWM) has emerged worldwide as the preferred model for watershed planning. IWM uses the watershed as the geographic planning unit while integrating social, economic, ecological and policy concerns with science to develop the best plan (Steiguer, *et. al.*, 2003; Heathcote, 1998; National Research Council, 1999).

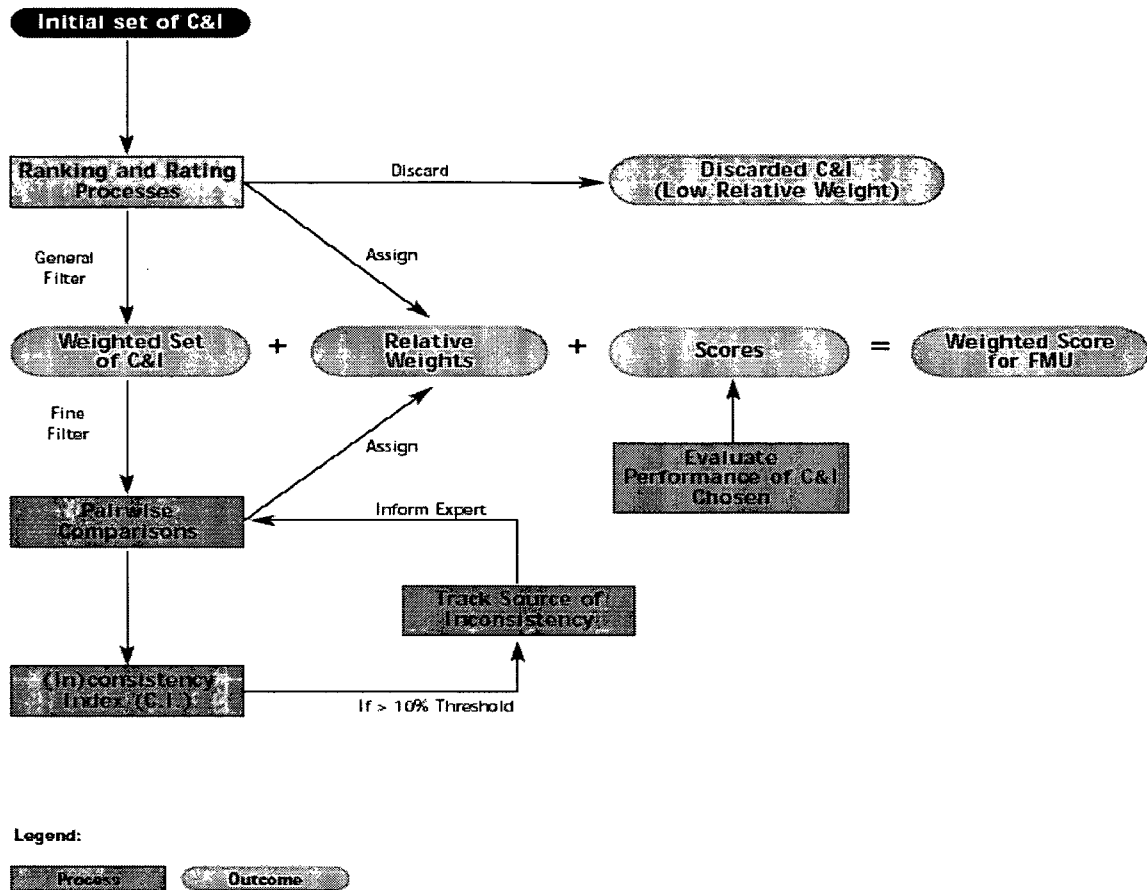


Fig -2.6: Combination of C&I concept and MCA approach (CIFOR, 1997)

Integrated water resource management plans are currently developed and implemented by various countries to organize the multi-sectoral water uses. On the other hand, it is necessary to be aware about the need for Decision support system as a tool for developing and implementing IWRM in a growing demand. In spite of lack of information gap around the world, the great potentiality of DSS for IWRM is not widely spread, planned and developed at the scale of territorial IWRM. Thus, Integration of DSS application to the existing IWRM systems at the target countries would assist in satisfying the water related Millennium Development Goals (MDGs) (Zeid and Afifi, 2006).

### **3 Materials and Methods**

#### **3.1 Literature review**

Literature is mostly collected from the internet, library of the Institute of Forestry and Environmental Sciences, forestry department, Institute of Silviculture-BOKU that helps me to realize the existing picture of the study area clearly by formulating existing prior problems and gathering knowledge. Also, I was able to collect map from each upazila or thana under each district for Chittagong Hill Tracts mentioning area, populations, male and female (%), Ethnic nationals, description of activities, different classification of hill eco-system, literacy and educational institute, newspapers and periodicals, cultural organizations, Main occupations, Land use, Market Value/0.01 ha value of land, main crops, extinct or nearly extinct crop, Main Fruits, Communication facilities, Traditional Transport, Manufactories, Cottage industries, Hats, bazars or fairs, main exports, NGO Activities, Health Centers. CIFOR guidelines, Map and Leizel report from SRDI on watershed of Chittagong hill tracts and official annual reports from CARITAS to reflect the current situation of the Chittagong hill tracts.

#### **3.2 Background studies**

##### **3.2.1 Work on principles, criteria and Indicators**

Planning of preliminary PCIV set started with problem identification through web searching, formulating research questions according to prior problems and continuous discussion with responsible forest managers in the selected project area. According to CIFOR 1999, Preliminary PCIV set helps me to accumulate and sort out the information. As, the demand to assess natural resource management has generally evolved the use of C& I because they appear to be highly capable of measuring, conceptualizing, evaluating different aspects of watershed management at national, regional or watershed level. Moreover, the concept of C&I has therefore become widely accepted as a suitable policy, management and research tool for easily understandable and simplified application for forest manager, policy makers and other user groups. Furthermore, the preliminary PCIV set helped me to analyze the current field situation and to get in-depth information based on the existing issues and the target objectives of research proposal outline. In addition, different components and main principles of the preliminary PCIV set were described with the discussion of experienced local responsible forest managers and research professionals through regular email contact and by phone.

Assessment of Criteria, Indicator and verifier for Integrated Water Resources Management (IWRM) in CHT can meet the demand of simplified information and vision; develop conceptual model; formulate potential indicators; and establish communication between stakeholders. It is a successful way to arrive at a 'consensus' or group-based evaluation (Weighted C & I) for IWRM in CHT of all Criteria/Indicators according to each individual/participant regarding the importance of each Criterion/Indicator.

Stakeholder input is the key and encouraging input for successful Integrated watershed management (IWM) to fulfill the multi-attribute dimension in the decision making process at CHT in Bangladesh, even, to find out the **best and compromise strategy** to enable an actual and productive work environment for the participants.

### 3.2.2 Field visit in Bangladesh

#### 3.2.2.1 Selection of research sites

I started my research work in Bangladesh with Co-Supervisor, Professor and Project Director of Upland Watershed Project in Bangladesh Dr S. M Sirajul Haque, in the Institute of Forestry and Environmental Sciences (IFESCU) through discussion about the problems and the selection of research site. He assured me, for getting lots of research papers and books relevant to my research work as well as he gave me some important contacts. I selected Soil Research and Development Institute (SRDI), Soil Conservation and Watershed management centre and surrounding areas of communities as research site according to the suggestion of Mr Jalaluddin Shoaib. According to Annual Report 1994 to 1995 from Soil Research and Development Institute (SRDI), Soil Conservation and Watershed management centre was established on 1994 in Bandarban of Chittagong Hill Tracts. It was the first attempt to set an ideal watershed model for Bangladesh.

According to Mr Shoaib, there are no actual works on watershed management. In the last project of SRDI, Bandarban, it was tried to train local people to produce their own food, fuelwood, and necessary materials for their residence. That project helped not only fulfill the need of the people but also favoured the environmental conservation of that area. The problem of the project was that trained people were not interested to join such type work. I selected three small neighboring watersheds of approx 1 ha and its surrounding villages as my research sites.

#### 3.2.2.2 Selection of key informants and groups

Total 18 key informants were selected according to working experience in the research site, CHTs. They were, 4 MSc students from the Institute of Forestry and Environmental Sciences, 4 field manager, 3 watershed specialist, 1 engineer, 1 journalist and 5 professors working in the Chittagong hill tracts, Bandarban. They were very skilled and experienced to explain the problems. They changed only some indicators of the preliminary PCIV set as the preliminary principles and criteria were quite convincing and acceptable to all. Most of them, were checking, whether all issues of IWRM are covered and checked. One of my declarations to my key informants was that they have the independence to change the PCIV set. That flexibility and freedom to give the preferences of the informants helped me to realize the degree of acceptability of preliminary PCIV set.

### 3.2.2.3 Procedure of getting information

A very simple and easy power point presentation helped key informants to understand the concept of principles, criteria, indicator and verifiers as well as systematic steps of filling the "Evaluation Preference Form". A complete explanation of each elements of the "Evaluation Preference Form" requires clarifying while key informants are giving their opinion about principles, criteria indicators and verifiers for "Integrated Water Resource Framework". Recording was very important instruments to get the real and complete explanation of the key informants and to know how to improve my attitude and behaviour and requirements as an individual researcher in the field. Final PCIV set was developed in discussion with Watershed specialist, Mr Jalal Uddin Shoaib by considering and justifying all comments and suggestions of key informants and started the "Evaluation work" after making correction, systematic and structured format through collaborating with Dr Harald Vacik.

To fill up the evaluation preference form was a tough work for key informants in the first impression of the format. After explaining each and every step, they were expressing their opinion and knowledge. The steps preference elicitation are:

1. Please, give your opinion or preferences for each principle, criteria and indicator according to the overall goal of an integrated water resource management.
2. Please, Start to rank the elements from 1- n and give scores to each element on a range from 1-100. For the criteria of each principle and for the indicators of each criterion you also have a range of 1-100 scores. For instance you rank principle 1 at second rank (25 scores) and you give 80 scores for 1.1 and 60 scores for 1.1.1 respectively.

### 3.3 Application of the Analytic Hierarchy Process

AHP has been applied in a large number of practical applications, mainly in economics and conflict resolution. Mendoza and Sprouse (1989) were the first to apply AHP in forest-management planning. More recently AHP is applying in multi-objective forest management and land-use planning due to simplicity, flexibility and high effectiveness in analyzing complex decision problems (Kangas and Kuusipalo, 1993; Schmoldt, *et al.*, 2001; Vacik, *et. al.*, 2006; Mendoza *et. al.*, 1999; Vacik and Lexer, 2001; Vacik, *et. al.*, 2001 and Ananda and Herath, 2003). AHP helps capture both subjective and objective evaluation measures, providing a useful mechanism for checking the consistency of the evaluation measures and alternatives suggested by the key informants thus reducing bias in decision making. Two important components of the AHP that facilitate the analysis of complex problems are; the structuring of a problem into a hierarchy consisting of a goal and sub-ordinate features of the problem and pairwise comparisons between elements at each level (Saaty, 1980, Zahedi, 1986 and Saaty, 2001).

### 3.3.1 Evaluation hierarchy of AHP

Structuring of a decision problem into a hierarchy helps to decompose complex problems into smaller parts. For the purpose of simplicity, a selection of PCIV set has been used for the AHP model. A total of 6 principles, 22 criteria, are used from the top (the more general) to the bottom (the more specific) according to the preferences of IWRM framework in CHTs system (Fig: 3.1).

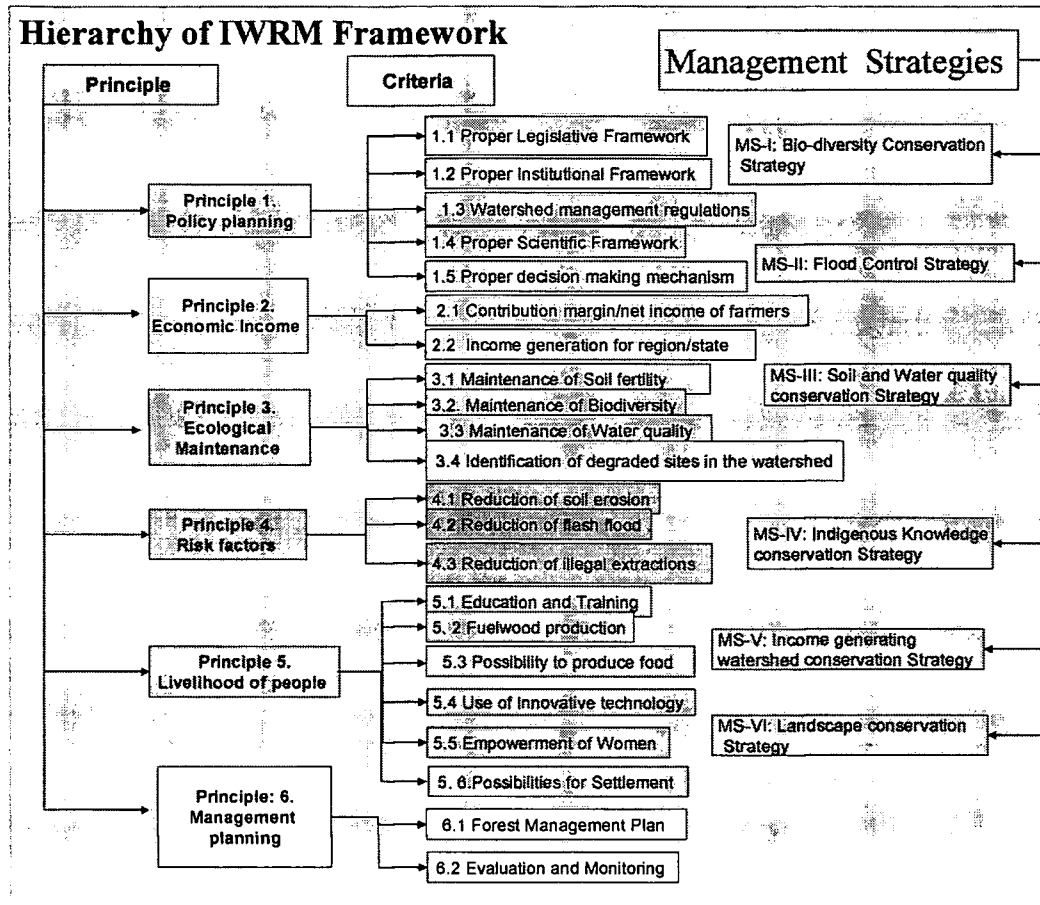


Fig – 3.1: Hierarchy of IWRM Framework of principles and criteria cascading from the decision objective or goal.

### 3.3.2 Pairwise comparison

Pairwise comparisons are made on a scale of relative importance where the decision maker has the option to express the preferences between two elements on a ratio scale from equally important (i.e., equivalent to a numeric value of one) to absolute preference (i.e., equivalent to a numeric value of nine) of one element over another (Saaty, 2001). The assessment of the management strategies for IWRM by making pairwise comparisons of AHP analysis has been done based on the key informants data provided during the interview. From this, relative weights has been determined, the importance of the criteria at each level of the hierarchy.

### 3.4 Characterization of research site

#### 3.4.1 General Background to the Chittagong Hill Tracts

Total area of Bangladesh is treated as watershed. Bangladesh can be divided into upland watershed and low land watershed based on the features and characteristics. The upland watershed, particularly hilly one, has greatest importance owing majority of its resources, and affecting low land watershed. Silting up water channels and flooding have been intensively affected upland watershed through shifting cultivation, illegal encroachment of natural resources, unplanned settlement and road construction without Environmental Impact Assessment (EIA). Rivers in this hilly watershed are faster and speedy than other parts of Bangladesh, being their courses mostly from mountains. Large number of hill torrents increases their flow suddenly after a good thunderstorm, which often leads to flash floods (Hewlett, 1982; Khan and Haque, 2003).

The Chittagong Hill Tracts (CHTs) occupies a physical area of 5.093 sq. miles (13,295 sq. km), constituting ten per cent of the total land area of Bangladesh (Roy, *et. al.*, 2000). The region comprises three districts: Rangamati, Khagrachari, and Bandarban with rugged terrain that contribute serious problems of soil erosion (Beattie, 1969). The districts comprise seven main valleys formed by the Feni, Karnafuli, Chengi, Myani, Kassalong, Sangu and Matamuhuri rivers aid their tributaries and numerous hills, ravines and cliffs covered with dense vegetation, which are in complete contrast to most other districts of Bangladesh, which consist mainly of alluvial lands. Geographically the CHT can be divided into two broad ecological zones: (a) hill valley, (b) agricultural plains. It is surrounded by the Indian states of Tripura on the north and Mizoram on the east, Myanmar on the south and east and Chittagong district on the west (Hassan, 1999; Khan and Haque, 2003; Shoaib, 1997; Wikipedia, 2007).

The land and water of the Chittagong Hill Tracts, is the south eastern part of the Himalayas, thus in stark contrast with mainland Bangladesh mountainous. In 1962 the Pakistan Government built a Dam at Kaptai, which inundated 45% of the fertile land of the CHT. Rangamati, the capital of the CHT is surrounded with water and mountains. From the time immemorial the CHT have been the home of thirteen indigenous ethnic groups. They collectively identify themselves as the Jumma people, the first peoples of the CHT. They are Chakma, Marma, Tripura, Tanchangya, Mro, Murung, Lushai, Khumi, Chak, Khyang, Bawm, Pankhua, and Reang. The Jumma people are distinct and different from the majority Bengali population of Bangladesh in respect of race, language, culture, religion and ethnicity (Khan, 2003; Haque, 2000; Roy, *et. al.*, 2000; Wikipedia, 2007).

The Chittagong hill tracts are inhabited by a variety of tribes, each speaking its own distinct dialect (Banik, 1998). Eleven indigenous groups and the Bengali communities who have migrated from different plain districts of Bangladesh and eventually settled in the region inhabit the CHT. The Bengali people are plain land cultivators, but some of them also practice farm forestry/agroforestry in the hills. The region's population growth of 3.4% per annum is almost equal to agriculture area growth rate of 4.4% for the last 50 years (1950- 2000). There is growth in number of farms only with no growth in actual crop income per farm or household. During the last decade (1990-2000), population growth has outstripped the agriculture area expansion

leading to acute marginalized and pauperized livelihoods. Stagnant agriculture growth indicates to constraints in the availability of land (ADB, 2001; Thapa and Rasul, 2006).

The region covers an area of about 13,181 km<sup>2</sup> and occupies about 76% of total 12% upland areas of the country and consists of 3 hill districts viz., Khagrachari, Rangamati and Bandarban with (Table-3.1 & 3.2) 25 Upazillas (sub-districts), 110 Unions (each union consists of 2 or more mouzas,) 380 mouzas( each mouza consists of 2 or more villages) and 3200 villages. Its population is about 1.4 million with a density of 122 people per sq. km (Table-3.1)(Khisa, *et. al.*, 2006).

Table-3.1: Areas of CHT hill districts with district-wise population and population densities

Hill Districts	Area(sq. km)	Population(2001)	People/sq. km(2001)
Rangamati	6089	588,000	96
Khagrachari	2590	490,000	181
Bandarban	4502	322,000	67
CHT region	13,181	14 00,000	122 ( Average)

Watershed of Chittagong Hill Tracts is rich repository of the natural resources. The natural climax is tropical evergreen. The headwater of the Sangu, Matamuhuri, Rinkheong, Kassalong and Maini rivers originate within Forest Reserves. The Forests are mainly two types: Tropical wet evergreen and Tropical Mixed evergreen. Both types of forest are multistoried in nature, provide a continued dense canopy, and litter cover to absorb the rainfall impact of the heavy tropical storms and to encourage rapid infiltration of the water into the soil mantle. Soil erosion is one of the challenging problems in Upland Watershed. Clearance of forests in Himalayan Watershed, in the hill of Tripura, Meghalaya and Chittagong Hill tracts, are making the existing condition of the degraded area more intensive.

Many hilly areas of Bangladesh are covered with lots of streams, creeks, canals and rivers. If it is possible to store water in Dam, then fish cultivation may proceed successfully with vegetable cultivation in the edge of the dam. In this way, local people may get vitamins and food in one hand; they will be able to use water as well on the other hand. Actually, small creeks and streams are getting filled by different types of degradation like deforestation, hill cutting, soil erosion, landslides, extraction of landslides, Flash flood, short rotation of Jhum cycle. People have been using those filled up sources to meet their minimum demand of water as they don't know what should be their standard of life style. It is now increasingly realized that policies and programs to promote sustainable land-use should be based on firm understating of the past; how past policies and course of actions conditioned the existing land-use practices (Niemeijer, 1996; Bryant, 1997, Hurst, 2003; Thapa and Rasul, 2006).

### 3.4.2 Historical background of the CHTs

#### 3.4.2.1 British Period (1860-1947)

Before the colonization of India (comprising present day Bangladesh, India and Pakistan) by Britain in 1760, almost entire part of the CHT was covered with dense forest. Shifting cultivation was the only agriculture practiced by tribal people to meet subsistence requirements (Lewin, 1860; Forestal, 1966; Thapa and Rasul, 2006).

Similar to other indigenous peoples of the world, the Jumma people were also independent before the British colonial period. The British annexed the CHT area in 1860 and created an autonomous administrative district known as "The Chittagong Hill Tracts" within the undivided British Bengal (Mohsin, 1997). Plough cultivation and sedentary agriculture, however, started gaining acceptance among the indigenous people when the vast area about one-fourth of land of CHT (1,345 sq. miles) was declared as reserved forest during the early 1880s and shifting cultivation was restricted there. It reduced the availability of land for jhuming (Thapa and Rasul, 2006).

By 1900, 4,453 ha of land came under sedentary agriculture (Khan and Khisa, 1970). The process of adoption was further accelerated by the population pressure, enhanced knowledge about plough cultivation and decreasing crop yield under *jhum* due to shortening fallow period. In 1960 it reached more than 40,000 ha (Khan and Khisa, 1970; Thapa and Rasul, 2006).

In 1900, the British enacted the Regulation 1 of the 1900 Act in order to protect the Jumma people from economic exploitation of non indigenous people and to preserve their traditional socio-cultural and political institutions based on customary laws, common ownership of land and so on. Throughout the British colonial period the 1900 Act functioned as a safeguard for the Jumma people, prohibited land ownership and migrations of non indigenous peoples in the CHT. In 1947, Indian subcontinent was partitioned on the basis of religion, Pakistan for Muslims and secular India for non Muslims and Muslims alike. Despite 98.5% of the population of the CHT were Jummas and thus non Muslims, the Pakistani leadership conspired and the Boundary Commission of Great Britain ceded the CHT to East Pakistan (now Bangladesh) in violation of the principles of partition and against the wishes of the Jumma people. The Jummas vehemently protested against the decision, but to no avail. Along with agriculture, policy changes were taking place in the forestry. Immediately after taking over the administration of CHT from the company, the colonial government made attempts to increase revenue from forest. The annual average revenue derived from the forest products increased substantially after 1871 as a result of such aggressive forest exploitation policies and the process of deforestation was further intensified (Khan, 2004; Khisa, *et. al.*, 2006; Thapa and Rasul, 2006).

#### 3.4.2.2 Pakistan Period (1947-1971)

This period witnessed the intensification of resource use due to construction of hydro-electric dam and migration of lowland people to the CHT, which influenced the land-use considerably. The predicament of the Jumma people began with the building of a hydroelectric dam in the early sixties which flooded 1,036 Square Kilometers of land submerged 40% of the

best arable land and displaced 100,000 Jummas from their ancestral homes. Some migrants from India were resettled in CHTs during the early 1950s. The government abolished the special status of CHT during the 1960s, which facilitated the large-scale migration of lowland people to CHT. As a result, within a decade between 1951 and 1961, the population of lowland Bengali in CHT had increased about five times, from 26, 000 to 119,000. Besides, declaration of some forests as 'protected forest', where shifting cultivation and collection of forest products were prohibited, accelerated the pressure on agricultural land. As a result of the combined effects of the increased number of shifting cultivators, decreased area for *jhum* cultivation, and increased population contributed by mainly immigration, population pressure on land increased significantly. This forced shifting cultivators to reduce the fallow period. Normally, they used to keep *jhum* plots fallow for 15-20 years till the end of the 18th century. By the 1960s, the average fallow period had been reduced to 3-4 years (Khan and Khisha, 1970; Forestal, 1966), which adversely affected crop yields.

As regards the use of forest resources, Pakistan Government followed the British policy of commercial extraction and started industrial use of forest products. It created Forest Industries Development Corporation (FIDC), which introduced new methods of logging that facilitated the extraction of timber from inaccessible areas. The newly adopted activity of forest products collection could not help much to improve their living condition, as they could earn a small amount of wage for cutting and carrying bamboo and soft wood to the nearest stream point. Realizing the adverse impact of shifting cultivation and necessity of rehabilitating degraded land, attempts were made by the government to promote horticulture based farming system in the late 1960s. About 3,000 households evicted by reservoir were allocated hillslope land at the rate of five acres each household, with inheritable rights, for mixed horticulture. Some of them successfully adopted banana, papaya, pineapple and other horticultural crops as cash crops, while others could not succeed due to lack of knowledge, marketing and credit facilities (Khisa, 1982; Roy, 1998). In some areas government agencies had established rubber plantation, the on trail basis, but this land-use could not expand as private entrepreneurs did not come forward due to lack of knowledge and marketing facilities (SHED, 1998; ICIMOD, 1999).

### **3.4.2.3 Bangladesh Period (1971- Present)**

After independence of Bangladesh in 1971, the Government of Bangladesh implemented a resettlement program to settle lowland people in CHT at the end of 1970s. It is estimated that 200,000 to 450,000 lowland people were resettled in CHT. Most migrants were resettled in *khas* land or government-owned fallow land, which was actually community-lands being utilized by indigenous people for generations (Barua, 2001). Indigenous people considered such land as their community property and, therefore, did not pay attention to securing land title from the government agency. Few indigenous people had land titles. As a result, many indigenous people were evicted from their ancestral land for the second time after their eviction by the construction of Kaptai reservoir during the Pakistan period. This undermined any investment in land development and management, and the indigenous people continued practicing *jhum*. Due to repeated slashing and burning, natural forest species were replaced by secondary vegetation such as shrub and hardy grasses (Arya, 2000; Roy, *et. al.* 2002; Thapa and Rasul, 2006).

### 3.4.2.4 The CHT Treaty

The Jana Samhati Samiti (JSS), the political platform of the Jumma people signed a treaty with the Bangladesh government on 2 December, 1997. The treaty failed to safeguard the survival of the Jumma people. The Bangladesh government did not have the sincere desire to solve the problem of the CHT. The treaty had rather been used by the Bangladesh government as a facade to impress the donor countries. The treaty does not address the fundamental problem of the Bangladeshi settlers and the militarisation of the CHT, it rather legalizes the settlers in the CHTs (Roy, *et. al.* 2002).

### 3.4.3 Hill Ecosystem

Based on vegetation characteristics (general appearance and floristic composition) ADB (2001) classified the hill ecosystems of Bangladesh as follows:

**Tropical wet evergreen forests** occur in deep valleys with abundant moisture and favors slopes of the hills. Common dominant tree species reaching an average height of 30 m are Chapalish (*Artocarpus chaplasha*), Chundul (*Tetrameles nudiflora*) and narikeli (*Pterygota spp*).

**Tropical mixed-evergreen forests** of Chittagong Hill Tracts are the habitat of over 1560 species of flowering plant-including 600 tree species. In addition, there are innumerable species of Bryophytes, Pteridophytes and three species of cycads (ADB, 2001). This tall multistoried forest occurs on hilly and undulating ground and alluvial flats. The emergent trees are mainly deciduous and reach a height of 60-65 meter. Principal species are Garjan (*Dipterocarpus spp*), Civit (*Swintonia floribunda*), Chundul (*Tetrameles nudiflora*) and Narikeli (*Pterygota alata*). **Tropical moist deciduous forests** occur on the edge of rivers and low lying areas. The principal tree species are deciduous e.g., Kadam (*Anthocephalus chinensis*), Jarul (*Lagerstroemia speciosa*), Simul (*Bombyx ceiba*), Pitali (*Trewia nudiflora*) and Bandarhola (*Duabanga grandiflora*).

**Tropical open-deciduous forests** occurs on dry exposed slopes with a southern aspect. Large trees occur as scattered individuals. Principal species are Koroi (*Albizia spp*), Pitali (*Trewia nudiflora*), Bandarhola (*Duabanga grandiflora*) and Champa (*Michelia champaca*).

**Bamboo forests** are found in abundance in the hill ecosystems of Chittagong Hill Tracts and Sylhet. It occurs either in pure patches or as undergrowth. Different bamboo species occupy ecologically different land types extending from the channel banks to the hill tops. The entire Unclassed State Forest lands are now covered by bamboo thickets bushes and low forest of non-commercial shrubs and planted species. Muli (*Melocanna baccifera*) is the predominant species, which occurs as pure stand or in associations with other species of bamboo over extensive areas. Other dominant forest bamboos are dullooa (*Teinostachyum dulloca*), Mitinga (*Bambusa tulda*), Kali (*Oxytenanthera nigrociliata*). The bamboo is used as a raw material to make pulp for paper mills. It is also used for house construction and supports many cottage industries.

**Homestead forest** of Chittagong hill tracts in addition to few forest tree species have clusters of fruit trees, e.g. Mango (*Mangifera indica*), Jackfruit (*Artocarpus heterophyllus*), Black berry (*Syzygium cumini*), Wood apple (*Angle marmelos*), Guava (*Psidium guajava*), Betel nut (*Areca*

*catechu*), Tamarind (*Tamarindus indica*), Plum (*Zuzubar jujube*) and Lemon (*Citrus spp*) etc. The homesteads, in fact, look like pockets of tree-covered areas within the denuded forest of Chittagong hill tracts.

Forests of the *Savannah* type are those where there are practically no trees. It occurs mainly in slashed and burnt for shifting cultivation. The main savannah species is Sungrass (*Imperata cylindrica*) due to overexploitation of a forestland. Not only the flora and mountains dominate the Chittagong Hill Tracts, but also fauna makes the area different. The wild and mighty elephant is one particular attraction of the Chittagong Hill Tracts. Once Bison, Sambur, Barking deer, Leopard, Royal Bengal Tiger, Panther and other animals were spread all over the Chittagong Hill Tracts. However, the numbers of most of these animals have drastically decreased today. Tiger species have gone totally extinct in the Chittagong Hill Tracts forest. Attractive bird species in Chittagong hill tracts include Imperial pigeon, Green pigeon, White winged wood-duck, Maina, Bhimraj etc (SHED, 1998).

The natural look and characteristics of the Chittagong Hill Tracts forest has been changed due to human intervention including plantation activities. Rubber plantations undertaken by the Bangladesh Forest Industries Development Corporation have not proven to be environmentally or economically successful. They have played a role in hastening deforestation and changing the natural character of the forests in Chittagong Hill Tracts (SHED, 1998; ADB, 2000).

Forestland and forests have an overriding influence on the environment of the Chittagong Hill Tracts. Once upon a time the species of the area were rich, three- storied, closed canopied tropical lowland rainforests of high biodiversity values and supposed to dominate unless disturbed by external influences. Currently tropical moist evergreen forests have virtually disappeared from the region. Especially in lower valleys, *Swintonia spp.*, *Dipterocarpus spp.*, *Hopea spp.*, *Sterculia spp.*, *Tetramelis spp.*, and *Artocarpus spp* were represented in the canopy storey of such forests. The middle stories were dominated species of the Meliaceae and Leguminoseae families. Only small pockets of this forest still survive.

Higher valley and lower hill slopes was covered with semi-evergreen forests. This forest ecosystem has a more open canopy with a large numbers of deciduous trees with well developed understorey of smaller trees and shrubs, epiphytes and climbers. A clumped distribution of a giant *Dipterocarpus spp* (Garjan) is characteristic for this forest type. Other canopy species include Civit (*Swintonia spp*) or, *Salmalia* and *Tetrameles*. Its second storey is well developed and includes species of *Amoora*, *Mesua*, *Cedrella*, *Bombax*. Lower stories contained a variety (ADB, 2001).

Where a forest canopy has 'opened' due to timber extraction or jhum plots, secondary species such as bamboos, vines and ferns invade. Fire disturbances can produce similar effect to the point where bamboo stands develop as a stable fire sub-climax ecosystem-completely replacing the primary forest species. Sub-climax formations of low open forest may also arise on drier and Sub-climax formations of low open forest may also arise exposed hill slopes with shallow soil. Much of the original forest cover of the Chittagong hill tracts has been logged and converted to jhum plots or to low shrub or grass vegetation such as *Eupatorium odoratum*, *Saccharum spontaneum*, *Imperata cylindrica*, *Arundinaceae spp*, *Mikania* vines and bamboo thickets. The

grass or shrub pioneer vegetation rapidly invades abandoned or fallow jhum plots except for the Sundarbans, there is a little available on the floral diversity of Bangladesh. Threatened plant species of Chittagong hill tracts are Ban supari (*Areca trianda*), Kadam bet (*Calamus erectus*), Chhoto bet mara (*Calliandra umbrosa*), Cycad (*Cycas pectinata*), Modon mosta (*Dehaasia kurzii*), Dholi Garjan (*Dipterocarpus gracilis*), Bon jalpai (*Elaeocarpus granites*), Homalina (*Homalium schlichii*), Kurud pata (*Licula peltana*), Jangli am (*Mangifera longipes*),

#### 3.4.4 Land use options in the CHTs

Depending on elevation, the hills can be divided into high, medium and low hill ranges with elevation of 350 m - >1000 m above MSL occurring in Chittagong Hill Tracts and Sylhet districts. The elevations of some notable peaks in these hills ranges are Mowdok Mual (1003.3 m), Ramiu Taung (920 m), Rang Talang (957.3 m), Keokradang (884 m). Medium high hill ranges with elevation of 100 m to 350 m above MSL occur mainly in north eastern part of Sylhet district. The region represents a very fragile hill ecosystem and is characterized by steep to extremely steep slopes (BANCAT, 2006)

Ideal Integrated production system for CHT hill slopes is different in different slopes like wetland crops, Food crops, Homestead garden, Agro-forestry, Tree-crop orchard and Timber species (Fig: 3.2)

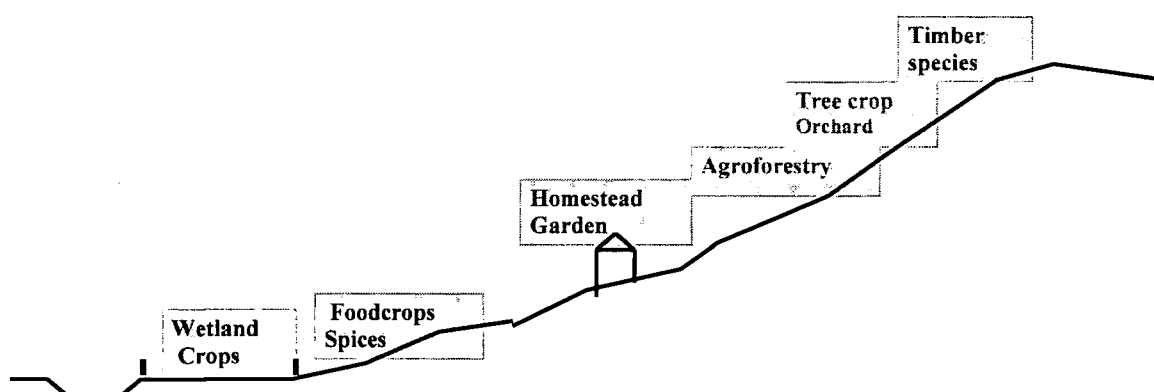


Fig – 3.2: Schematic ideal integrated production system for CHT hill slopes (ADB, 2001)

Land use options are broad for their different land capability zone. Intensive crop production, annual and perennial cash crops in hill land are suited in valleys, piedmont hills and lake fringe. Small scale irrigation, intensive field crop production with soil conservation, stable-fed animals, orchard crops, settlement schemes are done in low hills with valleys. Low hills without valleys are best land use for intensive field crop production with soil conservation, stable-fed animals and orchard crops. High hills with valleys are preferable for small scale irrigation, intensive field crop production with soil conservation, drought resistant orchard crops and community forest. High hills without valleys are the best options for subsistence crop production with soil conservation, stable-fed animals' drought resistant orchard crops, and community forest. Sub-sector like food crops (rice, maize, pulses, root crops), horticulture (fruits, spices, vegetables), Forest products (Bamboo, fuel wood, timber), Livestock (Chicken, cattle, pigs) and Fisheries are getting suggested programme priorities (ADB, 2001).

The elevation of some notable peaks in this hill ranges are Harargaj (335.8 m) and Tarap (122 m) and Low hills with elevation of 15 m to 100 m above MSL occupy along border line of Sylhet and Mymensingh, extending from Jaflong in the east to the Jamuna river in the west. These hill ranges are also found in the eastern coast of the Bay of Bengal from the Feni river to the Naf river. These hills also occur in between and outside the higher hills of Chittagong and Chittagong Hill Tracts. The Jaflong hills attain a maximum height of 61 m above MSL and elevation decreases to the West. *Chittagong and Chittagong Hill Tracts* are occupied by high north south striking hill ranges. The highest peak of the western most range of these districts reaches an elevation of about 304.9 m from the sea level at Sitakund. Towards the east, the ranges get higher and the slopes steeper until they reach the highest hill range in the east that marks the boundary between Bangladesh and Myanmar and India (Khan, 2000).

ADB (2001) suggested broad land use options for CHT according to different land capability zones including a list of the potential herbaceous and perennial crops (Table-3.8) for promotion under different hill farming conditions based on slope categories and accessibility to markets. ADB (2001) also outlined the programme priorities for the region based on major production systems in consideration of the constraints and opportunities of improved farming practices and provided a diagrammatic model of an integrated production system for CHT (Fig - 3.12).

### 3.4.5 Location of the study area

#### **3.4.5.1 An overview of Bandarban Sadar Upazilla or thana of Bandarban District, Chittagong hill tracts, Bangladesh**

Bandarban Sadar Thana is located at 21°55 North Altitude and 22°22 East latitude (Fig - 3.1). The area of Bandarban Sadar is 501.99 sq. km or 8,296 ha. Total population is 49,711 where 48% are migrated from plain land and 98 inhabitants/sq. km (Table - 3.2, 3.5) (WOCAT, 2006).

The average amount of land for each person is 1.02 ha. Among the populations, 56% are male and 44% are female; According to religion, 39% are Muslim, 47% are Buddhist, 7% are Hindu, 4.3% are Christian and others are 2.28%. Different tribal communities are marma, murong, tanchangya, bawm, khyang, tripura and lushei. Literacy is 34.5%. Daily newspapers are Jug Rabi and Natun Bangladesh; periodicals are Sangu and educational institutes are one Public library, one cinema hall, one Shishu Academy, one Shilpakala Academy, one tribal organization. The region represents a very fragile hill ecosystem and is characterized by steep to extremely steep slopes that limits its land capabilities, for examples, 4.9% area of Bandarban sadar are valley foot



Table-3.2: Land Capability Classes in CHTs (Forestal, 1966, Brammer, 1986)

Land classes	slope(%)	% of land outside reserved forest	Area(ha)	Land use limitations
A	<5	3.1	30,969	Few limitations
B	5-20	2.7	27,488	Moderate limitations
C	20-40	14.7	148,482	Severe limitations
D	>40	73.0	735,882	Very severe limitations
C-D	40-50	1.3	12970	Complex of C and D
Settlement and water		5.3	53,535	
Subtotal			1,009,326	
Reserved Forest			334,160	
Total			1343,486	

Table-3.3: Bandarban District under different slope classes including population and the density of population (ADB, 2001 and Brammer, 1986)

Different Upazila under Bandadban District	Total (sq. Km)	Valleys, foot slopes (class A land)		Class A, B, C land		Population		
	Area	Area	%	Area	%	Total	% migrated plainlanders	Inhab./km <sup>2</sup>
Bandarban. Sadar	501.99	24.6	4.9	29.6	5.9	49,711	48	99
Ruma	492.1	0.0	0	19.2	3.8	19,001	12	39
Lama	671.84	20.2	3	24.2	3.6	64,717	74	96
Rowangchhari	442.89	2.7	0.6	19.9	4.5	17,904	11	40
Thanchi	1020.82	0.2	0.02	22.3	2.18	16,104	10	16
Nakyongchhari	463.61	7.0	1.5	48.7	10.5	38,350	77	83
Alikadam	885.78		n.a.		n.a.	24,782	53	28
Total	4,479.03						52	51

Table-3.4: Bandarban District Areas (ha) under different slope classes (SRDI Manual)

Slope Class	Slope(%)	Bandarban (Area, ha)
Extremely steep	>70	160074
Very steep	50-70	142596
Steep	30-50	57381
Moderately Steep	15-30	28420
Gentle Slope	5-15	1220
Nearly level	<5	21952

Table-3.5: Micro-economic (Household) Farming Scenario in Bandarban Hill Districts (ADB, 2001)

Micro-economic Criteria	BANDARBAN hill districts
Annual Income or Cash & Non-cash	Taka 21,000 or 247 euro
Average Farm size	1.9 acres Jhum area
Homestead	0.05 acre( 200 m <sup>2</sup> )average
Wood lot(access to)	0.3 acre
Livestock	2 pigs, 8 chickens
Agricultural income	75% from Jhum, 25% from other source
Food shortages	6 months

Table-3.6: General Information of the research site, Bandarban Sadar (SRDI Manual)

Location	Bandarban Sadar Thana is located at 21 <sup>0</sup> 55 North Altitude and 22 <sup>0</sup> 22 East latitude
Name of the visited area	Bandarban, is Union of Bandarban Sadar Thana
Area	8,296 ha
Population	26,646
Population/sq km	98
Amount of land / person	1.02 ha
Ethnic nationals	Muslim 39.32%, Buddhist 47.1%, Hindu 7%, Christian 4.3% and others 2.28%.marma, murong, tanchangya, bawm, khyang, tripura and lushei.
Cultural Organizations	Public library 1, cinema hall 1, Shishu Academy 1, Shilpakala Academy 1, tribal organisation 1.
Literacy and educational Institute	34.5%
Main occupations	Agriculture 49.65%, agricultural labour 24.67%, wage labour 13.08%, commerce 3.65%, service 2.95%, others 6%.
Land types and area	1.Hilly Region: 44,250 ha that is 89% of the Bandarban Sadar Thana; 1.1 High Hill: 4,181 ha; 1.2 Medium Hill: 17,760 ha; 1.3 Low Hill: 22,309 ha; 2.Flood Plain Area: 4,052 ha that is 8.2 % of the thana
Water Resources	All streams and creeks originated from different small or high mountain meets into Sangu river.
Newspapers and Periodicals	Dailies: Jug Rabi and Natun Bangladesh; periodical: Sangu.
Main Fruits	Banana, pineapple, papaya
Cottage industries	Weaving, cane and bamboo works.
Main exports	Banana, bamboo, ginger, turmeric, tribal dresses

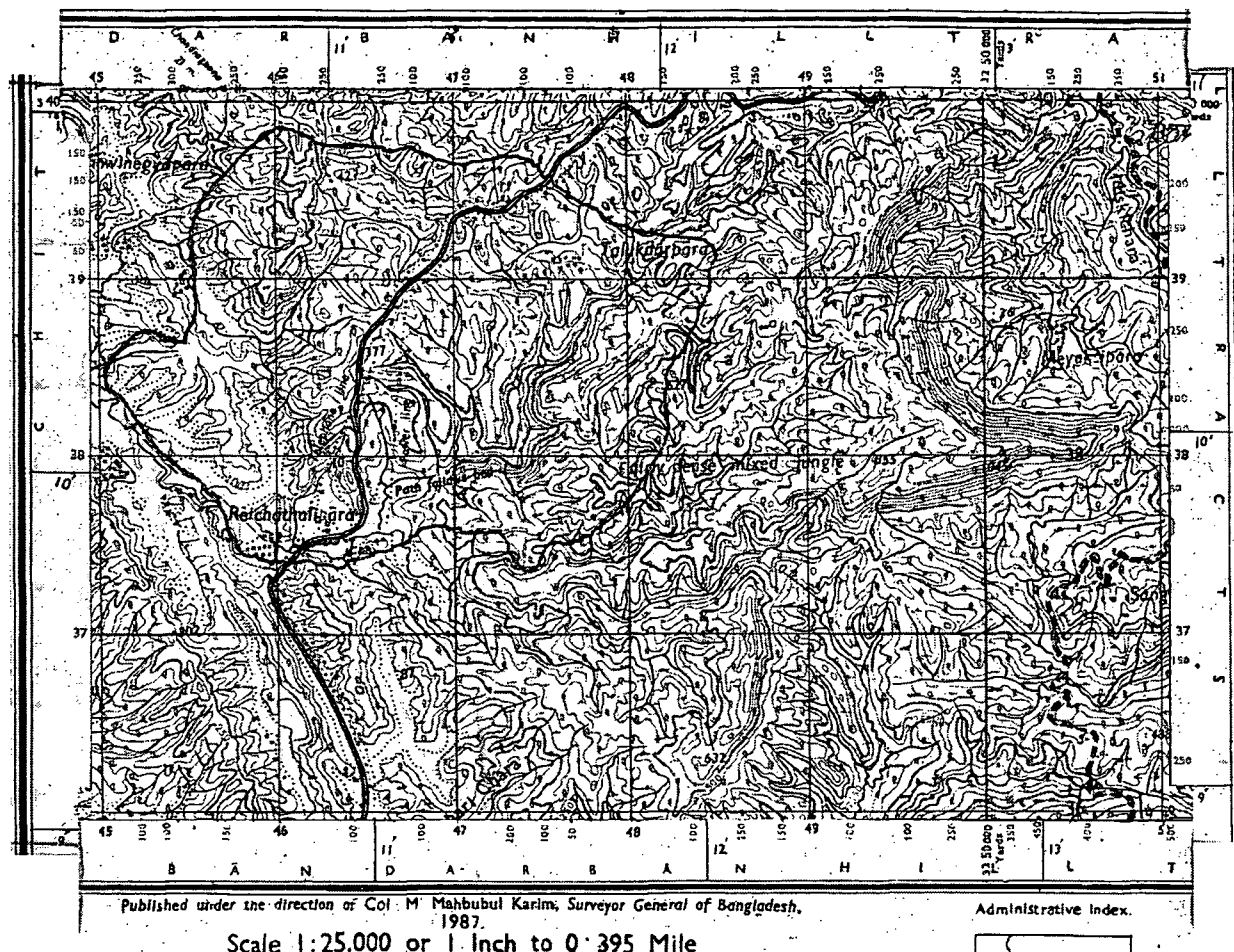


Fig - 3.4: Soil Conservation and Watershed Management Centre, Talukdarpara community” and “Reichathalipara community” in Bandarban Sadar (SRDI Map, 1987)

### 3.4.5.2 Soil Conservation and Watershed Management Centre and surrounding community (Selected project site) at Bandarban Sadar

The selected project area is the “Soil Conservation and Watershed Management Centre” in Bandarban Sadar of Bandarban district in Chittagong hill tracts of Bangladesh. It covers three small neighboring watershed catchment of approx 1 ha and the surrounding local communities (Gafur, *et. al.* 2003). The map in Fig - 3.4, is showing the location of Soil Conservation and Watershed Management Centre, Talukdarpara community” and “Reichathalipara community” in Bandarban Sadar covering three small neighbouring watershed catchments.

**Soil Conservation and Watershed Management Centre** was established at Bandarban Sadar thana in 1995. The main aim was to introduce modern hill cultivation with a suitable technology for soil and water conservation and watershed conservation strategy. Small catchment area of

approx 1 ha is managed by Soil Conservation and Watershed Management Centre, at SRDI, Bandarban Sadar Thana (Fig - 3.5). The project on participatory micro-watershed implies different components, 1) Annual crop area (Alley area, 20% and Terraced area, 20%); 2) Horticulture (20%); 3) Silviculture (25%); 4) Pasture + Hedge (5%), 5 ) Treated gully (10%) (Fig - 3.6)



Fig - 3.5: Small catchment area

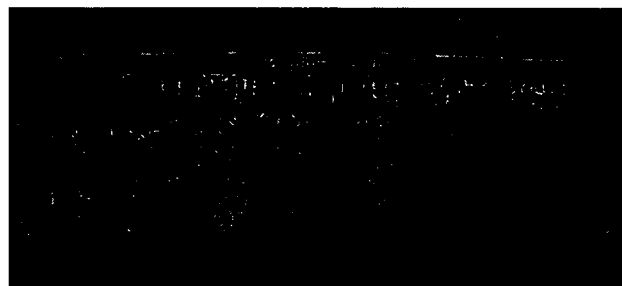


Fig - 3.6: Participatory Micro-watershed Model

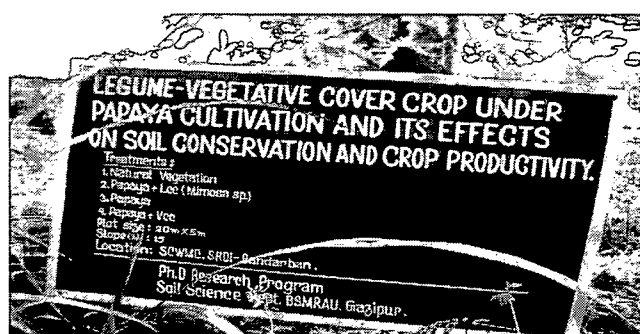


Fig - 3.7: PhD research programme

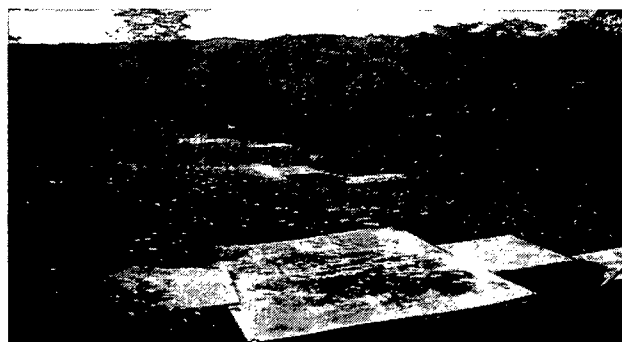


Fig-3.7: Multi slot divisor

Another research is ongoing on “Legume Vegetative cover crop under papaya cultivation and its effects on soil conservation and crop productivity” through the analysis of the effects of different treatments, 1) Natural vegetation, 2) Papaya+ LCC (Leguminous cover crop), 3) Papaya, 4) Papaya+ VCC (Vegetative cover crop), on 20m\* 5m plot and 15% slope (Fig - 3.7). Soil loss is estimated by multi slot divisor after introducing different conservation approaches.

Different conservation approaches by SRDI like, soil loss and run-off estimation is carried out under vegetative and mechanical (Terracing) Soil Conservation measures by multi slot divisor (Fig-3.7) under same cropping on steep hill slope to study performance of hedge, to compare cost-benefit ratio, to find out a good hedge species under hill environment, to study crop yield under different conservation measures and to estimate amount of NPK loss due to soil erosion. Research programme is done to see the effect of farming practices on soil loss, runoff, nutrient depletion and sustainable pineapple production in the hill slopes of CHTs (Table-3.7).

### 3.4.5.3 Description of community surrounding the selected project area

Talukdarpara Community and Rechathalipara Community are Mro or Murung tribe who are true aboriginal tribe of the CHTs region. They have their certain distinctive customs than other tribes. According to their own tradition, they immigrated to CHTs from Arakan several hundred years ago (Chowdhury, 2004). The simple and easy-going Mro-tribe is very much industrious and hard working people, but females work harder than their male counterparts in general (Baten, 2002)

The Mro tribe leads a community life. Headman is the head of the locality or mouja and karbari of whole Mro village. Karbari acts as a judge to deal with the judicial cases for villagers. They resides in the houses called “machang-ghar” as they build nine to twelve feet high wooden or bamboo made platforms on the high peaks of hills. There are large and small rooms inside their house that are built from the natural materials like bamboo, wood, cane, wild grass. Housing pattern of Mro tribe is almost made from forest products. Jhum or shifting cultivation is their subsistence agricultural system that brings the hilly lands vacant, bushy or degraded. Chicken rearing, broom preparation are observed in the study area for selling in the market; Plantation in the hill and fish cultivation in the pond. People are not aware of the cleanliness around their homestead, afterwards those wastes are falling in the water creeks, but communities are totally dependent upon river creeks for their household use and bath. So they are often attacked by different types of water borne diseases.

### 3.4.5.4 Development activities by CARITAS in the project area

*Integrated Community Development Project-Chittagong Hill Tracts (ICDP-CHTs)* by CARITAS is carried out to support people of CHTs for developing socio-economic, cultural and social harmony, particularly of the ethnic communities and the poor. Within a short period of time, the project has put raising awareness among the beneficiaries on various aspects of land, health, education, and human rights. Being aware of present realities, they are now more worried for future survival. However, they are also united to face the realities with courage and through collective efforts. In order to help them to cope up with the situation they are in need of financial and moral support (Table – 3.7). **Sustainable achievements are possible if the pilot project activities are possible to be continued by doing** some observable change like village based organizations are established, pre-primary education centers are available and functioning, people are aware of ownership right of land, primary health and family planning and safe drinking water is available.

Table- 3.7: Activities of Integrated Community Development Project-Chittagong Hill Tracts (ICDP-CHTs) by CARITAS

<b>Issues</b>	Achievements, problems, solution and Future directions
<b>Social achievements</b>	-leadership capabilities, management and dynamism, are created -legal awareness, human rights and gender development
<b>Economic achievements</b>	-small business small grocery shop, tea shop, etc are started from participant's own saving  -realize the significance of voluntary savings and have specific goal to do with savings (such as to bear educational expenses for their children in the near future, to invest in business). -more aware on use of safe drinking water and hygienic sanitary latrine.
<b>Environmental achievements</b>	-aware of their environment degradation. They observe the Environment Day and keep their homestead area clean.
<b>Problem faced</b>	-Due to lack of communication facilities, development agents are used to face lots of problems to reach the project area people.  -Field workers are often attacked by malaria, Diarrhoea due to lack of proper medical treatment  -In the season of shifting cultivation the Project Group members cannot attend the meeting regularly. Due to financial constraints, many of them could not afford the fees charged by headmen.
<b>Steps taken</b>	Group meetings are organized by-monthly basis, instead of by-weekly and in the evening. Contact with the headmen was made to convince them to make discount fee for the poor people. Motivate and build-up awareness among the PG members on Human Rights & the significance of preservation of land documents through issue based discussion, training seminar.
<b>Future Direction</b>	-Need to arrange skill development training for staff.  - Financial and moral support is needed to continue to ensure social dignity of local people through the ICDP project

(Source: CARITAS ANNUAL REPORT)

*Horticulture development project, CARITAS, Bandarban* has the goal to help people for socio-economic upliftment and settle people permanently on their own land since 1991. Specific purpose of this project is to increase the income status through establishing sustainability and profitable agricultural activity instead of leaving traditional cultivation. Selected families are assisted to get certificate for their ownership so that they can live on their own land and to develop socio-economic status of ethnic communities through integrating profitable and creative activity. Participants of this project are now more interested to implement agro-forestry system instead of shifting cultivation after realizing the disadvantages. Economic efficiency is increased through utilization of land in both winter and summer season by producing fruits and vegetables sustainably as well as doing other activities like dairy farm of cow, goat, pig, fish cultivation, small scale business etc. It is very nice that local people are preparing natural fertilizer by themselves and using in good agricultural production as well as contributing environmental conservation (Table – 3.8).

Table – 3.8: Activities of *Horticulture development project, CARITAS, Bandarban*

<b>Issues</b>	Social, economic and environmental achievements
<b>Social achievements</b>	-Regular group meeting and participation of different organizational activities, day celebration, seminar and training have been creating awareness among beneficiaries about the disadvantages of shifting cultivation and consequently their interest to implement agro-forestry system.
<b>Economic achievements</b>	-Cultivation of vegetables and fruits in both winter and summer season meet the demand of the family on the one hand, they are getting money for upgrading their life status by selling the rest of vegetables and fruits  - Dairy farm of cow, goat, pig; Fish cultivation, small scale business are increased
<b>Environmental achievements</b>	-Beneficiaries established pit from where production of natural fertilizer 100 ton. In addition, 240 metrikton fertilizer are supplied for organic farming or environmental friendly practice

## **4 Application of multi-criteria analysis for the CHT**

According to the web source of Ministry of water resources, there is an urgency to satisfy multi-sector water needs with limited resources, promote efficient and private responsibilities, and decentralize state activities where appropriate. The implementation of the Water Framework Directives in the EU's is a new task of policy for many water authorities, coinciding or even conflicting with spatial planning. Multi-criteria tools allow water resource management to search for efficient measures, which take into account to face immense challenge for resolving many diverse problems and issues (Dietrich, *et. al.* 2004). Learning based interactive multi-criteria methods provide a suitable solution for a dynamic and collaborative participatory decision making in a dynamic directive.

### **4.1 Assessment of current situation in Bandarban, Chittagong Hill Tracts**

According to BANCAT(2006), identified environmental issues are: deforestation, game hunting, adverse effects of short rotation jhum cycle, scarcity of drinking water, malaria and water-borne diseases, lack of health and sanitation, hill cutting, soil erosions, land slides, extraction of stones, flash floods - Thanchi, Ruma - (Shangu & Matamuhri Rivers), cyclones, soil erosion, land slides, crop damage by wild elephants - (Lama and Nakhyongchari) and tobacco cultivation in the Matamuhri river banks. This research study tries to set up a preliminary PCIV set (Principle, Criteria, Indicator and Verifier) according to analyzed problems of the Chittagong hill tracts. Afterwards, the PCIV set was prepared, discussed and assessed by different stakeholders like field managers, watershed specialist, Engineer, Journalists, students and professors. This PCIV set express what Integrated Water Resource Management means for the community of Chittagong Hill Tracts through the case study at Bandarban and assesses pre-defined targets according to the current situation.

**Principle (BOLD)**, Criteria (Underlined), Indicator (Normal) and *Verifiers (Italic)* for evaluating management strategies of Integrated Water Resource Management (IWRM)

## **Principle 1. Policy planning**

### **1.1 Proper Legislative Framework**

#### **1.1.1 Ownership and user right**

##### ***1.1.1.1 Ownership rights are ensured***

Current situation: No, ownership rights are not ensured. It is very tough to ensure ownership and user rights according to the complex administrative and political environment. CARITAS, ICDP and CHTs have few activities on land issues like basic legal awareness training on land issues and related laws. According to the National policy 1994, the participation and rehabilitation of the local jhum cultivators will be ensured under the auspices of the Ministry of Land in cooperation with the local government by keeping the land ownership rights intact (FSP, 2003; ADB, 2000; Kamal, *et. al.* 1999).

##### ***1.1.1.2 Local people are aware of their right***

Current situation: As local people of the study area, Bandarban are living far away from the city area, they are deprived of the facility of the main stream of the national economy. In addition, their life style, tradition, languages are different from the average people of the country. Different organizations started to reach to the grass level people. Lots of time and patience are essential for creating awareness among people to realize their own needs (Field Observation; ADB, 2000).

##### ***1.1.1.3 People are motivated for managing natural resources***

Current situation: Currently, local people are not enough motivated for managing natural resources. According to CARITAS, if ownership right is possible to ensure for people, they are convinced to take training and join development activities for IWRM (Field Observation).

#### **1.1.2 Strong Law Enforcement Capacity**

##### ***1.1.2.1 Active local institutions are organized for IWRM?***

Current situation: Local institutions are not organized for IWRM. So it is very impossible to follow the National Water Management Plan of 2004. But, IWRM sector is one of the three sectors of the bilateral development co-operation program between the Netherlands and Bangladesh since 1997. Proper functioning of Water Resources Planning Organization (WARPO) also may require legal covers in many aspects to implement the function like, "Cleaning house" so that all relevant water sector projects are carefully screened in conformity to the policy and NWMP.

##### ***1.1.2.2 Local level institutions are active to transfer messages in the central level institutions***

Current situation: As linkages between central and local level institutions are not effective, information's and problems of people are not transferred from local level to central level. So there is no need for effective work of central institutions currently. According to the achievement of rural sanitation, hygiene and water supply project, good partnerships with the DPHE (Department of Public Health Engineering) and NGO and Government supports the emphasis on communication and responding to demand (UNDP web).

### 1.1.3 Political Support and Awareness

#### *1.1.3.1 Local people are interested and aware about IWRM*

Current situation: The ministry of forest and environment arrange tree plantation activities and tree fair annually over the country to fulfill the target of the MDG, 20% forest land within 2015. Therefore, local people are convinced through mass awareness by political leaders about planting trees around surrounding vacant space of their educational institute and homestead. Department of Forest established 98 nurseries, 345 social forestry centres at upazilla level (Ahmed, 2002).

#### *1.1.3.2 Documentation of Indigenous knowledge about IWRM are encouraged, discovered and utilized*

Current situation: According to one survey, 35% of usable wood comes from Government Forest and the rest 65% comes from Village Forest. Even, 90% of usable fuel of the country comes from village forest, agricultural land. In ancient times, there were no projects importance about the forestry. Local people are used to do seed collection, seedling preparation and plantation from their native or indigenous knowledge. This type of knowledge is not well-documented and utilized practically. So it is very essential to conserve indigenous knowledge of planting tree as this knowledge can play very important role for implementing social and community forestry like species selection, selection of suitable place, plantation, maintenance and procurement (Goni, 1998).

#### *1.1.3.3 Advanced Research, Technology and Innovations are extended and utilized*

Current situation: Political party is conscious about the advancement of research, technology and innovations. BFRI (Bangladesh Forest Research Institute) and SRDI (Soil Research Development Institute) are trying to increase the knowledge and research about watershed management by different activities according to information transfer of research work, formulating organization like WOCAT (Field Observation).

#### *1.1.3.4 Political parties and local authorities are integrated and committed for implementing strong law enforcement*

Current situation: Political parties are incapable to link among themselves for national needs. It is very urgent to come forward for creating a strong commitment for natural resource conservation. Afterwards it would be easy to conserve watershed area of Bangladesh (Field Observation).

### 1.2 Proper Institutional Framework

#### 1.2.1 Strengthening multi-level institution

##### *1.2.1.1 Institutions are reformed to increase the effectiveness*

Current situation: Netherlands contributed for implementation of the National Water Management Plan in co-operation with Bangladesh Water Development Board (BWDB), the Water Resources Planning Organization (WARPO), and the Local Government Engineering Department (LGED) through focusing on institutional reform and capacity building. CHARM project coordinator, outlined the framework of cooperation, agreement between the European Union (EU) and the Government of Bangladesh (GOB). The Asia Pro Eco fund is designed to strengthen the environmental dialogue between Asia and Europe through the exchange of policies, technologies and best practices that promote more resource-efficient, market-driven, and sustainable solutions to environmental problems in Asia (Mantel, *et. al.* 2006).

#### *1.2.1.2 Community is hard working to organize themselves to be self-dependent*

Current situation: Village Development Workers play a vital role for creating awareness about the practice of hygiene after constructing tube-well by UNDP. Three meetings are organized in every month there where Village Development Worker presides over. The community learns hygiene practices. Such awareness leads to a qualitative change in life. Each member of the community paid Tk 20 or 15 cents as contributory amount of money towards setting up of the water point (UNDP web).

#### *1.2.1.2 Grassroots are influenced and benefited from different activities*

Current situation: Community centers are also centers for regulating the integrated programmes. Shishu Academy, government's education department and the ICDP project officials designed the book for pre-school children (UNDP web).

#### *1.2.1.3 The Institution is willing to listen to the Grassroots.*

Current situation: Yes, there are some good examples. ICDP (Integrated Community Development Project) is the result of a joint effort by the Chittagong Hill Tract Development Board (CHTDP) and the UNICEF. CHTDP was formed way back in 1976, with the aim of socio-economic development of the people living in the Chittagong Hill Tracts region. Government and UNICEF signed a 'memorandum of understanding on July 11, 1980. The programme focused on reducing child and maternal mortality, eliminating malnutrition, reducing of water borne diseases (the rate of which is high in the region), expansion of basic and primary education through formal and informal teaching methods, creation of self-employment through micro-credit programme (UNDP web).

#### *1.2.1.4 Time and Patience are ensured within institution to reach the goal of IWRM*

Current situation: No, time and patience are ensured, e.g., Sloping Agro-forestry Land use Technology (SALT) was very successful for nature and environmental conservation according to the project manager, but that project was stopped due to lack of fund (Face to face discussion).

#### *1.2.1.5 Village leadership Committee are the responsible media between local people and IWRM*

Current situation: Few community workers are contributing to the community after getting empowered through training. They are contributing to the development process as the responsible persons of their community through awareness building (UNDP web)

#### *1.2.1.6 Beneficiaries are discharging their responsibility*

Current situation: Village and Farm Forestry Project (VFFP) helps people to uplift their socio-economic condition through providing facilities for nursery establishment, services for extending forest plantation in the edge of the agricultural field. For example, Atikur from Gaibandha zilla started his nursery business from 1994 and now he overcomes his poverty through his hard work and patience (Krisikotha, 2005). Moreover, VFFP helps to get improved seedlings of 10 different mother trees of fruits from the Germplasm centre of the Agriculture University.

## 1.2.2 Acceleration and expansion of current activities

### *1.2.2.1 Local Enterprise are developed*

Current situation: Bangladesh small and cottage Industries corporation (BSCIC) of the project area is running so slow due to lack of raw materials like cotton, some chemicals for colouring the cotton. However, people of Chittagong hill tracts are very skilled for preparing different types of handicrafts from their indigenous knowledge. So if it is possible to incorporate some fund for BSCIC, they can employ more people to be self dependent instead of doing encroachment in the forest (Field observation).

### *1.2.2.2 Local level communications are expanded*

Current situation: Local level communications are trying to expand their activities by the developing organization in co-operation with some religious and cultural organizations (Field observation).

### *1.2.2.3 Skilled Human Resources are utilized*

Current situation: Vast amounts of investments are necessary for utilizing skilled human resources. Some NGO's are doing some activities like Sustainable Environmental Management Programme. They are trying to create awareness and involve people in conservation activities to overcome environmental degradation and poverty. Resource generating activities are nursery management, pond re-excavation for drinking and fish cultivation, sanitary latrine distribution, vegetable seed distribution, sapling distribution, road side plantation, tube-well set up, cotton cultivation, Bee-keeping, material distribution for rain harvesting (Field observation).

### *1.2.2.4 Loans are effective according to the situation*

Current situation: People are living under the poverty line, so different organizations are trying to help people through loan. Yes, loans are effective to the situation for those people who will be able to utilize the money, who are enthusiastic to join the activities. The given money must be monitored how they are utilizing so that money could not be misused. But very few people are misusing the funded money by the project (Field observation).

### *1.2.2.5 People are actively involved to the activity like tree planting*

Current situation: The Government encourage people through providing technical and other supports for planting tree on the courtyards of rural organization such as Union Parishad, school, eidgah, mosque-moktob, temple, club, orphanage home, madrassa etc. and other fallow land. People are more aware and involved about tree plantation than before (Field observation).

### *1.2.2.6 Watershed wise management projects are implemented*

Current situation: Yes there are some research activities, e.g., SRDI (Soil Research Development Institute) made some "Ideal model of Watershed Management" at Bandarban using different innovative technology. This model also needs scientific judgement and evaluation (Field observation).

### *1.2.2.7 Natural resource degradation is decreased*

Current situation: There are increasing trend of natural resource degradation as people are so poor, conservative and traditional. They know only that they will have to fulfill their stomach. To fulfil the stomach, they are engaged with different illegal extraction of different forest products

from forest. It is very essential to ensure food demand and they will be able to think about natural resource conservation (Field observation).

### 1.3 Watershed management regulations

#### 1.3.1 Existence of watershed management regulations

##### *1.3.1.1 A Watershed Certification is present*

Current situation: There is no system of watershed certification. Watershed certification is very important for sustainable management of upland degraded watershed because people will be motivated easily if they have their own land (Field observation).

##### *1.3.1.2 Effective land use management is implemented*

Current situation: The sense of effective land use management is really confined to research papers, website and brain of professionals, but not still applied in the practical field (Field observation).

##### *1.3.1.3 Watershed Inhabitants are convinced*

Current situation: Current time is to control the risk situation of the area through watershed management. People will be convinced easily if it is possible to create awareness about handling the possible risk in near future (Field observation).

##### *1.3.1.4 Representatives of farmers are efficient to explain the expectations of local peoples*

Current situation: Some farmers are really very efficient and keen to explain their problems. So, it is better to get the opinion from a representative's farmer rather than no opinion due to language differences (Field observation).

##### *1.3.1.5 Regulations are flexible according to situation demand*

Current situation: Poor people are not able to maintain regulations if they don't have food. Special case should be kept in mind during watershed regulations (Field observation).

#### 1.3.2 Emergence of watershed management group

##### *1.3.2.1 Groups are aware of solving problems urgently*

Current situation: There are no groups responsible for watershed management. Researchers, Journalists, Engineers, Professors and Students, feel emergency necessity of solving water problems, reducing poverty through "Integrated Watershed Management" (Field observation).

##### *1.3.2.2 Groups are responsible for maintaining the linkage of the framework*

Current situation: Existing problem is possible to be handled through a strong network of stakeholders concerning watershed management (Field observation).

## 1.4 Proper Scientific Framework

### 1.4.1 Skilled scientific research capacities

#### *1.4.1.1 Scientific research capacities relevant to IWRM are well known*

Current situation: IFEESCU (Institute of Forestry and Environmental Sciences, University of Chittagong) has some basic research on physical bio-logical and chemical analysis of upland degraded area. BFRI (Bangladesh Forest Research Institute) and SRDI (Soil Research Development Institute) have developed research work that is related to some component of Integrated Watershed Management (Field observation).

#### *1.4.1.2 Research results are conveyed to field experienced local representatives*

Current situation: Among various land degradation problems, causes and effects of shifting cultivation, hill cutting, clear felling, deforestation and burning on the watershed of Chittagong and Chittagong Hill Tracts have been reviewed, but not communicated to local representatives. Research findings shows that increase in population from 0.063 million in 1872 to 1.1 million in 1998 including settlers from plain land is one of the causes for severe degradation of watershed in Chittagong Hill Tracts. In this hill districts, 30 to 35 thousands tribal families are involved in shifting cultivation and 0.04 million ha lands are brought under shifting cultivation every year causing topsoil loss of about 4.2 million tons per annum affecting about 12329 km<sup>2</sup> lands. Deforestation is not only confined in unclassed state forest, but also occurring in the reserved forests in Chittagong Hill Tracts at a rate of 3.07% with a maximum destruction of 7.10% between 1980 and 1987 every year (Eliasuddin, 2005).

#### *1.4.1.3 Local users are convinced to follow the guidelines*

Current situation: Local people will be easily convinced to work if it is possible to monitor and solve their problems (Field observation).

### 1.4.2 Well defined precautionary and protective measures

#### *1.4.2.1 Watershed-scale best management practices are adopted and exercised*

Current situation: BFRI (Bangladesh Forest Research Institute) and SRDI (Soil Research Development Institute) finished experiments of watershed-scale best management practices, but those technologies are not adopted and exercised by the local people. SRDI (Soil Research Development Institute) is trying to incorporate some local people very technically for implementing different land use system instead of shifting cultivation. According to local representatives, local people are so simple but they don't have scope to communicate the harmful effects of shifting cultivation because many cultural and traditional values are incorporated with that cultivation system (Field observation).

#### *1.4.2.2 Each component of Watershed-scale best management practices is clearly defined*

Current situation: No activity is done by considering each components of watershed management. Researchers who are doing research on watershed, they are very conscious and well known about the knowledge of as well as degradation of that area. These knowledge may acts as foundation for further actions (Field observation).

#### 1.4.3 Exchange of technology and expertise knowledge

##### *1.4.3.1 Local people are free to express their opinion, demand and problems*

Current situation: CARITAS, Bandarban evaluate people's opinion where local people are very free to express their opinion, demands and problems (Field observation).

##### *1.4.3.2 Skilled professionals of developing organizations or researchers are ready to solve problems*

Current situation: Skilled professionals' feels, vast amount of fund is necessary to solve the problems (Field observation).

##### *1.4.3.3 International, technical and scientific co-operations are promoted*

Current situation: International co-operations are promoting day by day, but technical and scientific co-operation are confined to planning but implementation according to plan, are totally absent (Field Observation).

#### 1.5 Proper decision making mechanism

##### 1.5.1 Local People's and stakeholder's participation, communication and co-operation

###### *1.5.1.1 Participatory research action are ensured*

Current situation: Mr Md. Firoze Kibria, Vice Chairman of the Chittagong Hill Tracts(CHTs) Development Board(CHTDB), spoke about the rapid changes that are taking place in the CHTs. Ecosystem is becoming fragile and there is an urgent need to protect the bio-physical environment. Proper management of the environment is required to increase production of the cultivable lands. He emphasized the need for communities to live in a sustainable environment. Participatory action research should help to achieve this goal. Policies must support social justice and equity. He stated that cooperation of all the stakeholders, is vital for sustainable development and improvement of conditions for the people of the CHTs (Mantel, *et. al.* 2006).

###### *1.5.1.2 Problems of local resource mobilisation are solved*

Current situation: Mr Khan M. Ibrahim, Secretary of the Ministry of CHT Affairs, noted the successful development work of the CHTs in the last few years. He expressed a positive outlook towards future development activities. The regional council, a high-level body of 22 members from different communities with an elected chairman whose status shall be equivalent to that of a state minister, is supportive of the current work in the region. He is confident that CHARM will contribute effectively to the development of the CHT. He expressed confidence in the CHARM project and mentioned the support of (donor) agencies, including UNDP, EC, and the Government of Netherlands (Mantel, *et. al.* 2006).

###### *1.5.1.3 The Co-operation with Hill District Council is strong?*

Current situation: Yes, some developing organizations are trying to arrange some workshop for communicating planned activities, e.g., Workshop on the Chittagong Hill Tracts Improved Natural Resource Management (CHARM) Project, is the first of its kind, and thus all participants interact with open hearts and feel free to express their opinions (Mantel, *et. al.* 2006).

*1.5.1.4 Decision makers analyze decision problems through discussion with different stakeholders involved in these activities.*

Current situation: EGIS (Environment and Geographic Information System) and WARPO (Water Resources Planning Organization) have designed and are currently developing an analytical framework for Integrated Water Resources Management (IWRM) which will support the formulation, analysis and evaluation of alternative water management strategies of IWRM. CHARM will provide sustainable natural resources management options for improving the environment and reversing environmental degradation. Also, it will test and promote a sustainable natural resources management (NRM) planning technology. The results will include institutional capacity building and an improved information basis for decision making, i.e. Decision Support System (DSS) (Mantel, *et. al.* 2006).

*1.5.1.5 Decision makers are aware of people's opinion and preference.*

Current situation: In my project area, main problem is language difference and cultural difference with maximum people of CHT. I was speaking sometimes language of Chittagong and they were feeling very friendly to me. The best solution is, local people from their community must be involved to get their ideas properly (Field observation).

*1.5.1.6 A "Socially acceptable Policy" for sustainable management is facilitated*

Current situation: Socially acceptable Policy is not available for "Water Resource Management", but there are other programmes running by UNDP and CARITAS like "Food instead of Education". Rural people are sending their child to the school and Education Programme is expected for success (Field observation).

*1.5.1.7 Users are conscious to take part in decision-making and are committed to be present on time in participatory planning meetings*

Current situation: Field managers are not able to finish some planned work in time because it is impossible to call meeting in the morning during jhum cultivation season and jhum harvesting season. They are used to call meeting in the evening e.g., Development Training Workshop (Field observation).

**1.5.2 Appropriate, accessible, advanced and recent Information**

*1.5.2.1 All research works on Watershed Management are available in Internet.*

Current situation: Very few research work on CHT are available in Internet like WOCAT. Global society should know and come forward to create awareness for ensuring natural resource management of Watershed (Field observation).

*1.5.2.2 Problems are solved with the co-operation of global scientist group*

Current situation: No seminar is arranged to solve the problems in co-operation with Global scientists (Field observation).

*1.5.2.3 Annual documentation is available*

Current situation: Some developing organization like CARITAS do maintain annual report. Annual report from Government Organisation was not possible to collect during field trip in Bangladesh (Field observation)

#### *1.5.2.4 Progress and failure are easily understandable*

Current situation: Mr Ushatan Talukder, Member of the Chittagong Hill Tracts Regional Council mentioned that a Canadian firm carried out the first CHT survey in 1964. He noted some unfortunate events of the past, and advised that a congenial environment, law and order, and good initiatives from the government, are needed for effective development. He pointed out how the Regional and District councils are not functioning well at the moment and that historically there has been inadequate planning, evident in the continuing land degradation. The need for development partners to co-ordinate their planning efforts are apparent; he strongly advocated the preservation of the CHTs culture and tradition (Mantel, *et. al.* 2006).

#### *1.5.3 Multi-sectoral cooperation among organizations*

##### *1.5.3.1 Experiences of developing organization are documented*

Current situation: yes, developing organizations are documenting their activities and problems like CARITAS (Field observation).

##### *1.5.3.2 Discussion and participation of stakeholders are organized in a framework*

Current situation: CHARM is a one-year project funded by EU Asia Pro Eco. The partners include: the Center for Environmental and Geographic Information Services (CEGIS), Dhaka, Bangladesh; The Bangladesh Centre for Advanced Studies (BCAS), Dhaka, Bangladesh; World Soil Information, Wageningen, The Netherlands; and Lleida University, Lleida, Spain. The Rangamati workshop was organized to bring together policy-makers, experts, and other stakeholders (Mantel, *et. al.* 2006)

##### *1.5.3.3 Linkage among organizations are ensured to proceed in a continuous flow of development*

Current situation: Linkage between multi-sectoral institutions is absent. One sector, alone is not able to solve the multidimensional problems of Chittagong Hill Tracts as people of that area cannot realize how much environmental risk is existing there (Field observation).

##### *1.5.3.4 Do national, regional and local authorities exist for sharing opinions to fulfill the demand and problems?*

Current situation: Integrated centre of Mountain Development is serving their very few activities. According to , Dr. Stefan Frowein, Ambassador, Head of Delegation, of the European Commission, Bangladesh about Chittagong Hill Tracts Improved Natural Resource Management (CHARM) Project, It is pleasing, to see that a group of technical institutions from Europe and Bangladesh are working together with Hill Tracts people to form the firm technical base from which sustainable development might flow. To be sure, this is only the first step, but it is a good first step, which will now make it possible for development programmes and projects to be set up on a sound technical basis, making sustainability a possibility (Mantel, *et. al.* 2006)

##### *1.5.3.5 Users responsibility are awarded*

Current situation: Government initiated some awarding activities on “Tree plantation” (Field observation).

## **Principle 2 Economic Income**

### **2.1 Contribution margin/net income of farmers**

#### **2.1.1 Possibility of Local incentives/subsidies**

##### ***2.1.1.1 Incentives are appropriately provided for awareness raising***

Current situation: Appropriate planning of incentives is absent, but few organizations like SEHD organized training, seminar and workshop for 600 journalists from 100 newspapers and provides training to youth and leaders of the ethnic communities and activists at the CHTs (SEHD web source).

##### ***2.1.1.2 Incentives are adequate and utilized enough to fulfill the basic needs of people***

Current situation: People, who are utilizing money provided by NGO, can manage their food at least. They also provide other incentives to villagers like education facilities, medical facilities are provided by some projects (Field observation).

##### ***2.1.1.3 Income is generated through natural conservation***

Current situation: Eco-friendly and profitable agro-forestry help sustain people's livelihood under Social Forestry Project by CARITAS (Field observation).

##### ***2.1.1.4 Some technologies are experimented for the assurance of multipurpose needs***

Current situation: Few activities were done by BFRI, SRDI, IFESCU and some other NGO. They experimented multipurpose rain harvesting technology, community based seepage water harvesting (Field observation)

#### **2.1.2 Net income**

##### ***2.1.2.1 Threatened side of watershed are sustainably managed***

Current situation: Sustainable watershed management is a very new theme. It requires some time to create awareness about the conservation and sustainable management of threatened watershed in a productive manner. It is nice to mention that degraded sites of watershed are planning to be identified by IFESCU (Field observation).

##### ***2.1.2.2 Spontaneous production brings highest benefit through working with all the major stakeholders***

Current situation: As the area is very much far away from city and also, communication and transportation systems are so bad, major stakeholders do not feel good to invest their money in this area (Field observation).

##### ***2.1.2.3 Other offfarm activities (Agriculture, Piggry, Poultry rearing Apiculture Mushroom cultivation New weaving design others) are incorporated***

Current situation: yes, lots of developing organizations are trying to train the local people for making skill in off-farm activities (Field observation).

## 2.2 Income generation for region/state

### 2.2.1 Maximum utilization of resources are sustainably managed

#### *2.2.1.1 Extracting products from watershed area are adequate to fulfill the demand of daily needs like fuelwood production for cooking, fodder for their domestic animals*

Current situation: One conservation technology like Indigenous approach to Rain Water Harvesting can fulfill the demand of water for domestic use, irrigation, fish and duck farming(Face to face discussion).

#### *2.2.1.2 Illegal encroachment are decreased*

Current situation: Poor people traditionally collect their necessities from forest. Now-a-days, different activities like poultry, fruit production, handicrafts making are helping them to get more self dependent. If it is possible to show them other alternative way to earn some money, they will be aware about conserving forest (Field observation).

#### *2.2.1.3 Natural resources are utilized to produce income for people*

Current situation: Natural resources are utilized because nursery establishment, utilization of non timber forest products is getting popular within people to meet their daily needs.

#### *2.1.1.4 Alternative ways are ensured for Income generation from other resources (handicrafts, agricultural instruments, food, religious, musical instruments, sericulture, tourism)*

Current situation: Yes, some organizations are trying to ensure income generation through alternative ways, e.g., Bangladesh Sericulture Board (BSB) and Tourism industries implemented money for expanding sericulture and tourism in total upazilas in Rangamati, Khagrachari and Bandarban districts since July 2005. According to officials of BSB, the project created job opportunities for tribal, Bengali distresses and rootless people; suitable environment for production of small and cottage based silk yarn, women empowerment through income-generating silk related economic activities. Target group are trained with necessary training on rearing of silkworm and silk cocoon and silk yarn production. Ultimately, dependence of people on government relief could be reduced to a great extent through promotion of sericulture (Web source).

#### *2.2.1.5 Natural risks are prevented*

Current situation: Natural risks like drying up of natural water sources including streams, waterfall and see-page water are not taking into account for prevention (Field observation).

### 2.2.2 Compliances of international protocol for Natural Resource Conservation

#### *2.2.2.1 Activities on natural resource conservation for the fulfilment of International protocol are maintained*

Current situation: Many activities are planning to fulfill the international protocol, but how much activities are implemented, it is very hard to realize without monitoring and evaluation (Field observation).

## **Principle: 3. Ecological Maintenance**

### **3.1 Maintenance of Soil fertility**

#### **3.1.1 Growth potential (fertility of soil) for forest production**

*end = et al.*

##### ***3.1.1.1 Soil degradation and maintenance of water resource quality are recaptured***

Current situation: Soil erosion and forest degradation are widespread, causing loss of biodiversity, flash floods and landslides, declining productivity and water quality due to short rotation period of the slashed and burned systems. Some development organization feels, appropriate natural resources management, for soil conservation and water resources management, is essential for sustainable development in the CHT (Mantel, *et al.* 2006; Thapa and Rasul, 2006).

##### ***3.1.1.2 Biological, physical and chemical deterioration of these soils are identified***

Current situation: SRDI, BFRI and IFESCU are doing some basic research for identifying the exact Biological, physical and chemical deteriorations of CHTs. The traditional and widespread practice of shifting cultivation in small watersheds of the Chittagong Hill Tract is associated with profound changes in hydrological responses and soil quality. Thus, peak discharges may increase by orders of magnitude whereas the loss of soil and nutrients are significantly accelerated in the cultivation year (Gafur, *et al.* 2003).

##### ***3.1.1.3 Innovation technologies are extended for Appropriate Hill Farming***

Current situation: World Vision-Bangladesh, Bandarban started an Innovative Extension approaches for promoting Appropriate Hill Farming Technologies in few community (Field observation).

##### ***3.1.1.4 Responsible managers (e.g., Forest managers, soil conservationists and Field programmer) maintain documents and reports how much production is decreasing or increasing per year.***

Current situation: Some activities are done by the department of forest management that are not documented and reported (Field observation).

#### **3.1.2 Growth potential (fertility of soil) for agricultural production**

##### ***3.1.2.1 Soil nutrient budgets and balances are ensured***

Current situation: Still the theme of Soil nutrient budgets and balances is seriously limited to the paper of policy planning, scientific seminar and conference. There are no serious actions to combat the risk of conversion of vast amount of land into desert (Thapa and Rasul, 2006). At least, some research organizations like BFRI, SRDI and other organizations set up different conservation technology and approaches through experiment in different villages of CHT for making balance between soil and nutrients for agricultural production (Field observation).

##### ***3.1.2.2 Site suitability Map is maintained during site and crop selection***

Current situation: No site suitability map is maintained during site and crop selection. Different types of lands are used by local people to fulfill their basic needs (Field observation).

### 3.2 Maintenance of Biodiversity

#### 3.2.1 Conservation of Floral and faunal richness

##### *3.2.1.1 Important hotspots of bio-diversity are conserved*

Current situation: Some cultural and religious organization like Parbatya Bouddha Mission have been contributing for nature conservation in CHTS through involvement of people in different conservation works (Parbatya Bouddha Mission web site) .

##### *3.2.1.2 Negative impacts of key threats like floods, waterlogging, intensity of storms, landslides and water scarcity are trying to be handled*

Current situation: Preventive measures are very requisite according to the situation than cure. CARITAS has one project on “Disaster Management” that is responsible for providing relief and rehabilitation during flood, house support for wild elephant victims, Winter cloth distribution for cold wave victims(Field observation) .

##### *3.2.1.3 NTFP and other indigenous species are conserved*

Current situation: No, there are no conservation centre to preserve NTFP and other indigenous species. The history of the use of NTFP, e.g., medicinal plants for alleviation of diseases has its origin since primitive times. Illness, physical discomfort, wounds, and fear of death forced primitive man to use the natural substances around him. According to past records, Babylonians (about 3,000 B.C.) were aware of a large number of medicinal plants and their properties. Some of the plants are still used today in the same way and for the same purposes. The earliest use of the medicinal plants in the Indian subcontinent is found in the *Rig Veda* (4,500–1,600 B.C.), which noted that the Indo-Aryans used the Soma plant (*Amanita muscaria*), a narcotic and hallucinogenic mushroom, as a medicinal agent. The *Vedas* made many references to the healing powers of *sharpagandha* (*Rauvolfia serpentina*), while a comprehensive Indian herbal book, the *Charaka Samhita*, cites more than 500 medicinal plants (Gani, 1998).

##### *3.2.1.4 Mountain ecosystem is protected, recovered and restored.*

Current situation: According to a National Report of Bangladesh, plans are done to prevent and mitigate the negative impacts of key threats to mountain bio-diversity for promoting sustainable use of mountain bio-logical resources through survey on medicinal plants and documentation of traditional knowledge (Web sources).

##### *3.2.1.5 New methods are developed, applied, and tested for sustainable management of the natural resources*

Current situation: A diverse group of people from international, national, and local level organizations are coming towards for working in the Chittagong Hill Tracts. They are trying to find an alternative for sustainable management of the natural resources. (Mantel, *et. al.* 2006).

##### *3.2.1.6 Collaborative plan are done for transferring technology to end-users*

Current situation: Collaborative plan of different research organizations have been developed for transferring technologies to end-users. Training and education programmes are arranged but people do not have awareness to use the training skill (Field observation) .

### 3.2.2 Reduction of threatened patented right

#### 3.2.2.1 Medicinal Plant Reserve are conserved

Current situation: No, there are no systematic and planned organizations for “Medicinal Plant Reserve” (Field Observation).

#### 3.2.2.2 Sufficient raw materials for commercial purposes are available

Current situation: The total recorded number of plants with medicinal properties in the subcontinent at present is around 2,000. About 450 to 500 of these have been listed as growing or available in Bangladesh. Conservation of biodiversity is fundamental to the success of the development process. As the medicinal plants are directly related to the health of a large number of people in Bangladesh, appropriate steps should be taken to ensure their conservation. Although there is no reliable data on which medicinal plants require conservation efforts, there is an agreement that most natural ecosystems are threatened and that forests resources are being exhausted. Most of the forests in Bangladesh have been heavily exploited and biodiversity is being depleted at alarming rate. There is a chance that some useful species may go extinct even before being discovered. Priority should be given to those medicinal plants that are most at risk of becoming endangered or going extinct (Gani, 1998; Yusuf, 2004)

#### 3.2.2.3 Ethnic values are preserved

Current situation: Ethnic values like traditional ecological knowledge of indigenous women are not preserved and utilized in the management of natural resources and the preservation of biodiversity (Field Observation).

#### 3.2.2.4 Different organizations are available for maintaining the TRIP rights

Current situation: The WTO declared the Trade-Related Intellectual Property Rights (TRIPS) during the Earth Summit on the Convention of Biological Diversity (CBD) accorded, in 1992, as a sovereign right to a state of its biological resources which hitherto were regarded as the heritage of mankind. TRIPS Article 27.3(b) made provisions for, the first time ever, Intellectual Property Rights (IPR) such as patents or a *sui generis* system, on plant varieties, provided the varieties are new, involve an inventive step and are capable of industrial application. In addition, there are 29 least developed countries, including Bangladesh, who are members of WTO and whose deadline for implementation is January 2006. Most of these countries lack the capacity to address the complex issues surrounding the TRIPS Agreement (Web sources)

### 3.3 Maintenance of Water quality

#### 3.3.1 Improve surface water quality by environmental protection measures

##### 3.3.1.1 Natural resource management and protection of environmental health are sustainable.

Current situation: The Chittagong Hill Tracts rural communities are living beside the river, rock canal/chara, and spring and some are living on the top of the hill. This type of habitat is common phenomenon in CHT rural areas. All natural prime water sources are degraded and gradually cause contamination, deforestation, land slide, plant life burning, soil erosion, waste and garbage dumping. Some plantation activities are encouraged, but people cannot afford the cost of buying seedlings (Web sources).

### *3.3.1.2 Sustainability of traditional water sources are conserved*

Current situation: There is no scenario of water resource management and practices for conservation of traditional water sources through the Government departments, international donors and NGOs. Some developing programme are providing safe water technologies with free of cost, some where cost sharing by the community, high priority is given to safe water technologies for influencing new projects, rather than for maintaining and rebuilding the traditional systems with the view to sustainability of prime natural water sources; springs, streams, rock channel, and other traditional sources in this regions (Field observation).

### *3.3.1.3 Realistic and achievable long term resource management plan is done*

Current situation: No, there is no long term resource management plan. Hill Tracts Foundation (HTF) is trying to initiate a development education program on 'Conservation of Natural Water Sources and Environment Management' for capacity building of communities, sustainability of natural water sources, defining water rights and entitlements and strengthening local water management with new skills and methods. CHARM (Chittagong Hill Tracts Improved natural Resources management) started a workshop on 15 February 2006 (Web source).

## **3.3.2 Improve ground water quality by environmental protection measures**

### *3.3.1.1 Risk of ground water quality are clearly identified*

Current situation: In Bangladesh, the groundwater level is being depleted at an alarming rate and creating crisis in water output. Experts warned if depletion of groundwater continues for the next few years there is likely to be a big change in soil structure in the water table in a few decades. Following this incident Bangkok decreased the dependency on groundwater. According to Nurul Haque, WASA's (Water Supply and Sewerage Authority) chief engineer "Groundwater does not get recharged automatically as there is no open space to accumulate rainwater. It threatens the quantity and quality of water," (Web source).

### *3.3.1.2 In-situ moisture is conserved based on the percolation of water under-ground*

Current situation: Immediate action is essential to characterize aquifers for better understanding of groundwater flow, and modeling of aquifers to be utilized for better management of groundwater (Field observation)

### *3.3.1.3 Natural regeneration of indigenous vegetation, soil conservation and enhancement of moisture regime are enabled*

Current situation: Groundwater in most parts of the country therefore becomes the only possible source of water for irrigation, domestic and industrial purposes in the dry season. But one major concern in groundwater is that of arsenic which threatens to affect human health in the southern parts of the country and also hamper further growth in the development of groundwater. The challenge for groundwater in Bangladesh is therefore to find mechanisms to maintain agricultural needs, ecological sustainability and human health requirement (Field observation)

### 3.3.3 Severe water crisis problem are reduced

#### *3.3.3.1 The severity of water crisis is properly noticed by the governments and donor*

Current situation: BFRI, ICIMOD, CHARM, VCF project, SRDI jointly arranged an approach “Introduced approach to Gravity flow Water Supply System from foothill Seepage Water Sources” for 25 families of Sanguipara Community People, Bandarban Sadar Upazilla. The aim was to make availability of water for domestic use (WOCAT, 2006) .

### 3.3.4 Environmental protection of available water resources like rivers, estuaries, lakes and water depression are sustainably managed.

#### *3.3.4.1 Traditional water management are implemented by local stakeholders*

Current situation: Indigenous Approach to Rain Water Harvesting approach is to construct a small earthen dam locally known as *Goda* at the suitable footslopes for storage of water for domestic water use, irrigation, fish and duck farming. The water run off down the hill is collected in the rainy season. Excess of rain water collected in the *Goda* is drained out through the out-lets prepared in one side of the earthen dam. In preparing the dam, the farmer first prepared bamboo mats placed at the both sides of the earthen dam and then earth cuttings were put to form the dam. The individual farmer with his/her own efforts and cost established the earthen dam (WOCAT, 2006).

### 3.3.5 Blocked or threatened water reservoir are urgently cleaned and managed

#### *3.3.5.1 Blocked water bodies are cleared and managed*

Current situation: Water bodies are seriously in endangered situation where water is not suitable for domestic use, fish production at least. Day by day, water bodies are filled up with lots of soil erosion form the hilly areas (Field Observation)

#### *3.3.5.2 Fish productions are ensured*

Current situation: Some NGOs like IUCN, CARITAS are making some people self dependent by giving training and giving some money for investing fish production (Field Observation)

## 3.4 Identification of Protective areas

### 3.4.1 Survey of existing threatened watershed

#### *3.4.1.1 Sites of Watershed identified*

Current situation: It is nice that I found one sentence in the National Forest Policy 1994, “Inaccessible areas such as slopes of the hills, fragile watershed, swamp etc. will be identified and kept as protected forests.” Knowledge on watershed and watershed management has a long record in Bangladesh. Yet studies on watersheds and watershed management are lacking (Field Observation).

### 3.4.2 Planning program for watershed management.

#### *3.4.2.1 Land use classification systems in watershed are used*

Current situation: Yes, lands are used considering different gradients of slope from traditional knowledge. Topographically, the whole Bangladesh watershed is divided into floodplain, terrace and hill, constituting 80%, 12% and 8% land, respectively (Hewlett, 1982 and Khan, *et. al.*

2003). There is no planning for different land uses in watershed, but some local people are using their indigenous knowledge on various slopes of the hill producing agricultural crops on the plain land and horticultural species and forest species on the upland area.

#### *3.4.2.2 Land use for reforestation are determined*

Current situation: It is very essential to determine how much land area requires to be reforested. But there is no plan to do this task (Field Observation and discussion)

#### *3.4.2.3 Monitoring and evaluation program are set to restore basic watershed and ecosystem processes*

Current situation: Strict documentation is absent there. So, it is very tough to understand the on-going activities by different developing organization (Field Observation and discussion)

#### *3.4.2.4 Local people are aware of the impact of traditional hill farming system*

Current situation: For a balance patterned "slash and burn" farming, a hill ideally needs 15-20 years of interval to recover. In past, the land and man ratio was ideal and the expected interval in the jhum cycle was maintained. But presently, because of excessive population, this interval has reached to 2-3 years, which is extremely insufficient to allow the vegetation growing and to recover the forests. This vicious cycle of jhum cultivation is one of the major reasons of depleting indigenous forests, also a precondition for drying of the springs (Field Observation and discussion; Nath, *et. al.*, 2005; Thapa and Rasul, 2006)

## **Principle: 4. Risk factors**

### **4.1 Reduction of soil erosion**

#### **4.1.1 Soil and water conservation measures are appropriate**

##### *4.1.1.1 Forest along the water catchment area are conserved and managed*

Current situation: No, there are no activities for conserving forest along the water catchment area. The depletion of indigenous forests is causing the increase of temperature and the decrease of precipitation. Thus, the whole spectrums of environmental changes are resulting into the water crisis in CHTs (Field Observation and discussion)

##### *4.1.1.2 Plantation materials are available*

Current situation: Very few NGO and sometimes Government provide some plantation materials during “Environmental Day” Mass nursery are necessary to establish to make the available plantation material to people (Field Observation and discussion).

##### *4.1.1.3 Innovative technologies for waste management are utilized*

Current Situation: Waste of households are scattered beside the house. After rainfall, all wastes are going towards water catchment area and polluting water (Field Observation and discussion)

#### **4.1.2 Construction of cross dams with bio-engineering technology**

##### *4.1.2.1 Enormous drains, and compartments are constructed*

Current situation: Infrastructure conditions are very bad and are not managed to combat the serious attack of flood in low land areas (Field Observation and discussion)

##### *4.1.2.2 Technical, economical, environmental, socio-political, and ecological grounds are the basis of management.*

Current situation: Mass actions are absent for risk management of soil degradation through different stakeholders in CHTs (Field Observation and discussion).

#### **4.1.3 Sloping land management with best practices are preferable for environmental conservation**

##### *4.1.3.1 Protection of soil loss are dealt with advanced research and technology*

Current situation: Yes, adopted conservation approaches with research and technology are available for soil protection. Fund is necessary to implement those approaches (Field Observation and discussion).

##### *4.1.3.2 Traditional Jhum cultivation are replaced technically*

Current situation: People will kill conservation workers if they say to stop jhum cultivation, but it is possible to replace it with other technologies. Because fallow period of jhum is not possible to maintain due to population growth, so their jhum cultivation are not satisfactory like past time (Field Observation and discussion).

#### *4.1.3.3 Threatened Landslides are marked*

Current situation: Threatened landslides are not marked for landslides control in CHT (Field Observation and discussion)

### 4.2 Reduction of illegal extractions

#### 4.2.1 Reporting and handling illegal extraction of resources

##### *4.2.1.1 Demands of timber are assessed*

Current situation: No, report is available about the intensity of illegal extraction of timber. (Field Observation and discussion)

##### *4.2.1.2 Mass plantation programme are encouraged*

Current situation: yes, mass plantation programme are encouraged (Field Observation and discussion)

##### *4.2.1.3 Punishment of illegal extractor is effective*

Current situation: Punishment of illegal extractors is not effective as the administrations are not successful to catch the illegal encroacher (Field Observation and discussion)

##### *4.2.1.4 Local people are conscious about handling the illegal extractor*

Current situation: Local people are aware of mass illegal encroachment of illegal extractor. They do not have power to handle the problem (Field Observation and discussion)

#### 4.2.2 Separate forest plantation for supplying excessive demand of industry by their cost

Current situation: No, there is no separate plantation to meet the demand of industry (Field Observation and discussion)

##### *4.2.2.1 Illegal commercial raw material collection are stopped*

Current situation: No, institution is working seriously about illegal commercial raw material collection (Field Observation and discussion)

### 4.3 Reduction of flash flood

#### 4.3.1 Formulating solutions for flooding problems

##### *4.3.1.1 Flood Zoning and Risk Mapping (FZRM) are done*

Current situation: After the devastating flood of 1998, Bangladesh once again witnessed an unprecedented flood in the year 2004. The majority of the country went under water for at least one month. Disruptions and damages to economic activities and loss of lives/properties caused by the flood were quite significant. After the floods of 1987 and 1988 a lot of attention was drawn and a Flood Action Plan (FAP) was initiated. The Government declared the Bangladesh Water and Flood Management Strategy (BWFMS) in 1998 as an outcome of the FAP studies. Many of the BWFMS concepts were carried forward onto the National Water Policy (1999). It is also prudent to prepare a medium-term strategy as well as a long-term strategy based on all previous experience. The strategy should be based on the most effective combination of measures to secure and enhance the community's asset base and measures to provide improved external

services. In this context, Flood Zoning and Risk Mapping (FZRM) is considered to be urgently needed (WARPO, 2006).

#### *4.3.1.2 Forecasting and Early Warning and Monitoring Report is available*

Current situation: Bangladesh is probably the world's most flood-prone country. It mostly comprises the combined delta of three major rivers: Brahmaputra-Jamuna, Ganges, and Meghna. These rivers drain a combined catchment of some 1.55 million square km, 11 times greater than the area of Bangladesh itself. The low deltaic terrain, extreme rainfall in nearby hills, and high flows from these large catchments mean that over 20 per cent of Bangladesh is inundated in a 'normal' flood year; more severe floods regularly cause loss of life and economic suffering. I found that Bangladesh country office, Disaster preparedness and Response Section. Flood Monitoring is done on the basis of the Flood Forecasting and Warning Center (FFWC) rain gauge data. The data used to generate the rainfall map originates from the US based NOAA (National Oceanic and Atmospheric Administration) Climate Prediction Center (CPC)(Web resources). Remote sensing aerial photography is being used in Bangladesh since 1930s and 1940s for cartographic mapping, forest inventory and water resources studies. The use of satellite technology started with the establishment Automatic Picture Transmission system in 1968 that have been tracking all the storms formed in the Bay of Bengal and necessary forecasting and warning through Bangladesh Meteorological Department (Pramanik, 1994). But, Forecasting and Early Warning and Monitoring Report is not available in the study area(Field observation)

#### *4.3.1.3 Constructing culvert, development of embankment, road at flood level and excavation of canal are done*

Current situation: No activities are going on for constructing culvert, development of embankment, road at flood level and excavation of canal (Field observation).

#### *4.4.2 Planned activities are implemented*

##### *4.4.2.1 Initiatives are sufficient to ensure supply of food and medicine to the flood victims while setting up shelter centers and using different materials to erect houses*

Current situation: The farming communities of Bangladesh living in the flood prone areas have been practicing the dapoge method for many years. They have adopted the techniques to cope with floods and continue with their livelihood. They use their own capacities and finances for this. This method has great potential not only for farmers in Bangladesh but also for other countries. This method is already widely in use in the Philippines and in some regions of India. Through the diversified and holistic intervention for the flood prone communities, some positive changes and improvement in their livelihoods pattern were visible (ITDG, 2001)

##### *4.4.2.2 Upper riparian areas are brought under one umbrella for co-operative approach*

Current situation: International Rivers originating from Himalaya of Nepal coming down to their ultimate destination, Bay of Bengal. They pass through the land of Nepal, Western India and Bangladesh in one way and some of the rivers pass through Bhutan, China, India and Bangladesh. Bangladesh is located at the lowermost reaches of the international rivers and at the confluence of Bay of Bengal is at high risk for drought, flood, salinity and shoal formation. The most important region of flooding in Bangladesh is due to either sudden opening of sluice gates of the barrages of upper reaches of the rivers and or continuous and heavy snow melting by high

temperature or combination of both.. There is no co-operative approach among upper riparian countries for augmenting water production, conservation and preservation through watershed management instead of implementing unilaterally prepared river linkage project. For example Farakka dam in Ganges basin is a name of nightmare for 140 million people of Bangladesh that was built without consultation with the downstream riparian state of Bangladesh (Payne. et.al.2003 ) and began operating on 21 of April 1975 (Abbas, 1982).

## **Principle: 5. Livelihood of people**

### **5.1 Education and Training**

#### **5.1.1 Educational Status**

##### ***5.1.1.1 Primary/secondary education of children are ensured***

Current situation: Education Local Consultative sub-Group (ELCG), International Development Cooperation For Education in Bangladesh updated their activities for Primary Education (PEDP) with DPE, Secondary Education with DSHE / DTVE, Non formal, post-literacy and continuing education through MoPME and Direct support to NGOs/ INGOs, other agencies. For example, CHOLEN as an Education Project of CARE-Bangladesh – CHOLEN started operating in the CHT since May 2000 after a comprehensive livelihood assessment of the region. CHOLEN focuses on three main objectives: to increase access to basic education, to improve quality of basic education and to enhance system of education through increasing accountability and capacity building. At the initial stage the project had only 25 schools and later with financial support it has expanded to cover 180 schools (66% government schools, 18% non-government registered schools where 80% of teachers salary are borne by the government and 15% community schools which do not have any financial assistance from the government) and more than 15,000 children. The project is sponsored by USAID and CARE-USA. In addition, CARITAS, ICDP, CHTs has set up 21 community based education center (Chowdhury, 2003; CARITUS, 2004).

##### ***5.1.1.2 Training for management of natural resources and commitment towards socio-economic upliftment***

Current situation: Very few developing agency has the programme for arranging training management of natural resources and commitment towards socio-economic upliftment

(Field observation).

##### ***5.1.1.2 Trained knowledge are applied***

Current situation: Few people are applying and utilizing trained knowledge About 1.3 million people in the Chittagong Hill Tracts (CHT) in the south-east corner of Bangladesh have remained largely outside the mainstream of development assistance for more than 25 years due to insurgency and instability in the area. Despite the signature of the CHT Peace Accord in 1997 the flow of development assistance has not been forthcoming due to the slow pace of the peace process on the one hand and the critical security situation on the other. With a safer working environment for development workers re-established by the UNDP International and the three District Councils, donors support is now being intensified. The implementation of the 1997 peace accord is central for the livelihood and the development of the Hill Tracts. Modest but still visible progress is being made in a joint effort by the CHT Institutions on which development measures can build. CARITAS, ICDP, CHTs and SEHD have some programme on skill development of their staff like land reformed and gathering of landless people, preparation of family and society for disaster management, Gender development, Monitoring Orientation, Follow up training on Legal Awareness, PRA, Social issues and CHT analysis, Human Rights (EC, 2006; CARITUS, 2004 and SEHD web sources).

#### *5.1.1.3 Funding is assured*

Current situation: Sufficient funds are not available for involving all needy people. Now, fund is available to International partners to improve the status Primary Education (PEDP) and Secondary Education (Field observation and Web source)

#### *5.1.2 Technical assistance for implementing innovative technologies*

##### *5.1.2.1 Innovative technology is successfully reach to the people*

Current situation: Local forest managers demand support by a needs-based extension system. This involves a radical re-organization of technical expertise in the forestry sector, moving forest technicians from State Forest Enterprises into forestry extension centers, introducing new extension methods for assisting local forest managers, and developing suitable agro-forestry systems for dissemination (Field Observation)

#### *5.1.3 Maintenance/transfer of Indigenous knowledge*

##### *5.1.3.1 Participatory approach are maintained to apply their Indigenous knowledge*

Current situation: No initiatives is done for intensive application of indigenous knowledge (Field Observation)

##### *5.1.3.2 The knowledge base- myth or reality are used for land use and water use decision making*

Current situation: According to FAO (2000), it is suggested that it is particularly necessary to recognize the reality or myths relating to forests and water because, not only do forestation and deforestation activities account for the largest area of land use change occurring in the planet (Calender, 1998; 1999). As local people can not communicate with decision making authority, so valuable and important myths are not recognized and used for land and water use decision making (Field Observation).

##### *5.1.3.3 Sustainable Forest management are ensured for IWRM*

Current situation: There is no sustainable forest management that can ensure freshwater needs, water resource management and development (Field Observation).

#### *5.1.4 National groups are constituted*

##### *5.1.4.1 Available conscious groups are working to accelerate the activity*

Current situation: Good practices from Bangladesh, China, India, Japan, Thailand and Vietnam were closely studied through field studies, interviews and literature review; and then challenges to the promotion of LINK-based sustainable resource management were examined. The framework of LINK SPOs was developed to address these challenges accordingly (Web sources)

##### *5.1.4.2 Immediate actions for extending awareness are ensured*

Current situation: The National Water Management Plan of Bangladesh (2002) highlights that water will become the key issue for sustainable development in Bangladesh in the future. During the last 50 years, a large number of water development projects have been implemented by different agencies, which are mainly concerned with physical interventions for flood control, drainage and irrigation. In parallel, major development in road infrastructures has taken place. As time progresses and more projects are completed, interdependency of these kinds of projects with the surrounding water environment has resulted in a number of adverse impacts. Some of the

adverse impacts include increase in the depth, duration and extent of inundation in the unprotected areas, increase in sedimentation rate in the drainage channels, increase in flood levels, drainage congestion in the protected areas, loss of fish habitats and breeding grounds. This trend is likely to continue in the absence of any integrated approach to water and land-use management (Field Observation).

## 5.2 Fuelwood production

### 5.2.1 Amount of fuelwood production from “Homestead forests”

#### 5.2.1.1 *Homestead forests are managed and protected*

Current situation: Homestead forests are not actively managed. Officially, nations have kept natural forests as reserved forests where people access is stopped. But, surrounding is so poor and they are totally dependent upon forest. People who have space around their home, they usually plant some fruits, and timber species to fulfill their basic needs (Field observation and Hossain, 2004).

### 5.2.2 Amount of fuelwood production from plantations

#### 5.2.2.1 *Demands of fuelwood are fulfilled*

Current situation: Homestead forests are supplying major portion of fuelwood demand in the country. People require some financial assistance for getting available planting materials (Field Observation).

#### 5.2.2.2 *Nations are benefited*

Current situation: Near about 40 acres of degraded forests have been planted with native species; Nations are benefited for the expansion of homestead forest (Web source).

## 5.3 Possibility to produce food

### 5.3.1 Commercial Fruit production (e.g. Pine-apple, Jackfruit, Lemon Guava, Orange, Banana, Papaya and other)

#### 5.3.1.1 *Highly productive seeds are sufficient*

Current situation: Highly productive seeds are not sufficient. Some developing projects are working to uplift socio-economic status of poor hilly people through introducing environment-friendly and highly diversified “Horti-silvicultural farming system” incorporating timber, fruit, and gradual replacement of production decline (Web source).

#### 5.3.1.2 *Nursery is scientifically managed*

Current situation: Eco-restoration nursery’ model for the hilly areas has been finalized. People who have money, they can manage their nursery scientifically. Maximum nursery manager are poor, they cannot bear the extra cost (Web source).

#### 5.3.1.3 *Marketing facilities are arranged*

Current situation: Commercial Fruit Business requires some advancement in infrastructure development (Field Observation).

#### *5.3.1.4 Problems are monitored and reported*

Current situation: The project, CARITAS Horticulture Development Project could not supply the targeted amount of seeds due to high market price (Field Observation).

#### *5.3.1 Small scale enterprises are established*

##### *5.3.2.1 Weaving, cane and bamboo works, poultry are available*

Current situation: Some NGO like, UNDP, BRAC, ASA and CARITAS are giving some training and money to people to be self dependent (Field Observation).

##### *5.3.2.2 Some job facilities are available*

Current situation: Job facilities are not available as stakeholders are not available for creating enough employment opportunities (Field Observation).

##### *5.3.2.3 Illiterate people are self dependent*

Current situation: Average people are illiterate. So they can earn some money if they can have some skills for producing small industries products (Field Observation).

##### *5.3.2.4 Market demand are taken into consideration*

Current situation: Some cottage industries are producing very good products that are standard for export so that nations can achieve foreign money (Field Observation).

#### *5.3.2 Technical and experienced local representatives are recruited*

##### *5.3.2.1 Market is systematic*

Current situation: Marketing system is very bad where people do not get proper return after selling their products. WFP (World Food Programme) launched the Expanded Food Assistance (EFA) Programme in the CHTS on August 1998 for three-year pilot basis. Over 95 percent of present EFA beneficiaries are women. WFP is providing these beneficiaries with food assistance, combined with a development package that covers awareness building, health and nutrition topics. This will expanded to include skills and income-generation activities to enhance the programme's sustainability. The development of the CHTs, and in particular its vulnerable population, is a high priority on the agenda of GOB and its donor partners. The Government is involved EFA with food assistance being channeled through three of its departments - the Directorate of Relief and Rehabilitation (DRR), the Department of Local Government & Engineering (LGED), and the Department of Fisheries (DOF). These departments in turn utilize resources in the three following programmatic areas, Livelihood Support Intervention (LSI), Integrated Fish Culture and Road Maintenance Programme (RMP). It requires long time to arrange required facilities (UN, 2007).

##### *5.3.2.2 Information about price of different products are available for selling to buyer*

Current situation: There is no price information about products. Local people are deprived of getting appropriate marketing facilities (Field observation and discussion)

### 5.3.3 Fisheries

#### *5.3.3.1 Tools for pisciculture are available*

Current situation: Integrated farming (duck and fish) are in place to meet the fish demand. People usually made tools from their own knowledge (IUCN web source).

#### *5.3.3.2 Demand of protein is ensured*

Current situation: Many hilly areas of Bangladesh are covered with lots of streams, creeks, canals and rivers. If it is possible to store water in Dam, then fish cultivation may proceed successfully with vegetable cultivation in the edge of the dam. In this way, local people may get vitamins and food in one hand; they will be able to use water as well on the other hand.

Some NGO like WFP creates awareness to utilize ponds as a fish reserve. For example, A pilot project, Integrated Fish Culture where short-term laborers receive food as wages for the excavation of ponds or the construction of dams for community-based creek fishery cultivation. Fish culture activities have already begun in a number of excavated water bodies in three hill districts. Meanwhile further attention is being given to developing nursery ponds to combat the shortage of locally available fingerlings. The continuous access to pond water enables horticulture and poultry farming on the pond-banks and provides an important source of early income. A total of 5,718 laborers have earned food-wages through the programme, while 46 fish farming groups are currently operative. Few people who have money, they can do fish cultivation (web sources).

### 5.4 Use of Innovative technology

#### 5.4.1 Crop Production (Rice, sesame, cotton, turmeric, ginger and vegetables)

##### *5.4.1.1 Many innovative technology are observed for sustainable crop production*

Current situation: Yes, sustainable crop production is available. But it needs fund to implement (Field Observation).

##### *5.4.1.2 Innovative technologies are trying for adoption*

Current situation: WOCAT documented conservation approaches as a report, but it is far away from adoption (Field Observation).

##### *5.4.1.3 Biofencing is maintained for protecting crops from wild animals*

Current situation: People are used to use bio-fencing for protecting crops from wild animals (Field observation).

##### *5.4.1.4 Composts are using for getting vigor growth of vegetables*

Current situation: Sometimes people use cow dung or make compost after creating a hole beside their home. The hole is filled with leaves, twigs, and wastes of poultry. Afterwards, natural fertilized build up after mixing all wastes with soil (Field Observation).

## 5.4.2 Herbal Medicine

### *5.4.2.1 Medicinal needs are solved in a cheap way*

Current situation: Poor people can solve their small medicinal needs using medicinal plants; Maximum people have medicinal plants in their homestead for cultural and religious traditions (Field Observation).

### *5.4.2.2 Raw materials of pharmaceutical and aromatic industry are available*

Current situation: Medicinal plants are becoming extinct as lots of pharmaceutical industries are producing medicine, some aromatic company are producing shampoo, soaps and other different products from medicinal plants (Field Observation).

### *5.4.2.3 Nursery of medicinal plants is available*

Current situation: Various extension works are done by Government level annually through arranging tree fair and creating awareness for establishing nurseries. Some industries can spend money to build some rich nursery for making available raw materials of medicinal plants, as a result, the reserve of medicinal plants will not be extinct (Field Observation).

## 5.4.3 Water Conservation, storage and farming in dry season.

### *5.4.3.1 Tools for harvesting rainwater are managed*

Current situation: People are used to use Bamboo as a pipe and their handmade rope for collecting seepage water (Field Observation).

### *5.4.3.2 Water is secured for the dry season in a cheap way*

Current situation: Green Hill builds a reservoir beside the stream and set up a pipe from the uphill to the households of nearest villages. Those pipelines are very few according to the demands of the local needs e.g., 4 or 5 tape for 130 households (Field Observation).

## 5.5 Empowerment of Women

### 5.5.1 Sufficient Training to acquire food security

#### *5.5.1.1 Women are the real work force and backbone of tribal economy*

Current situation: Most of the beneficiaries are women. Most of the tribal area is female dominated, so family dependent upon income of mother. Recent UN conferences have advocated that women's empowerment is central to development. Different international conferences regarding Integrated Water Resources Management (IWRM) i.e. International Conference on Water and Environment (Dublin 1992), United Nations Conference on Environment and Development (UNCED 1992), the Second World Water Forum (The Hague 2000), and International Conference on Freshwater (Bonn 2001), focus on the very crucial aspect of the involvement of local communities participation in all phases of water management. Women are not fully involved due to their crucial role in the practical day-to-day supply, management and use of water (Field Observation).

#### *5.5.1.2 Daily activities and seasonal calendars are maintained*

Current situation: Education is the key factor to empower women, her ability to work for future generation, facilitating her voice for her own right, decision making power, consequently the overall positive changes of the world. In South Asia, promoting female education is now critically important. Initiatives of Bangladesh government can be a good example. In 2002 Bangladesh government announce free education for female up to twelve grades and also providing scholarship for female students and also for their parents in rural areas. Traditionally women are used to maintain different cultural and religious activities in different months. They can understand different seasons without following any calendar (web sources).

#### *5.5.2 Women access are shared, documented and evaluated to all natural resources*

##### *5.5.2.1 Women are involved and aware to achieve their rights*

Current situation: According to Millennium Development Goal 3, Bangladesh will have to increase the female: male participation ratio at tertiary levels from 36:64 to 50:50 to ensure gender disparity within 2015. But still, it is a distant goal in Bangladesh about true empowerment and recognition of women as income producing agents is not promoted for empowerment, education, and positive social changes (GoB and UN, 2005). But, Government initiated some coata system for tribal people in each university of Bangladesh. So, people of that area are getting updated day by day. Many organizations like SHED and BITA are working to come out the rights, problems and knowledge of the local people (Field Observation).

##### *5.5.2.2 Women's are responsible for contributing in IWRM*

Current situation: Women's are responsible for maintaining the family by providing food, water and firewood for cooking and heating makes women very aware of water quantity and quality and environmental degradation and determined to do something about it. So it is necessary to take initiatives to facilitate women access to all natural resources in a meaningful and effective way. Due to language and cultural differences, existing situation realization for women is difficult. It needs some patience and time(Field Observation).

#### *5.6 Resettlement in hilly area are organized*

##### *5.6.1 Settlement are planned and organized without harnessing environment*

##### *5.6.1.1 Government is conscious for natural resource management of the re-settlement area*

Current situation: Environmental Impact Assessment was not done before settling people in Chittagong Hill Tracts. Total population of CHT was 124,762 in 1901, and this population size has become 1,325,041 in 2000. In each decade, the average growth of national population was approximately 18 per cent while in CHT it was 47 per cent till 1997. The population has grown here abnormally because government during the 1979-1997 periods patronized the "Bengalis" living in the plain land to be settled in the CHT. This migration of people from other parts of the countries caused an abnormal growth of population in this region (Alam, *et. al.*,2004). According to (DFID, 2002), Country strategy objectives for livelihood of people have little impact in CHTs due to delays and subsequent deprioritization.

#### *5.6.1.2 Input settlement after assessment of carrying capacity of the area*

Current situation: During the decades of the 80s and the 90s, the population increased at the rate of 48 per cent and 67 per cent respectively. This abnormal growth of population has upset the total demographical and ecological equilibrium in the CHT. Presently the proportion of indigenous to Bengali population has become 52:48, as opposed to 97.5: 2.5 in 1947 (Alam, *et. al.*, 2004). Conflict for land scarcity in Bangladesh increased due to chronic flooding, river erosion and environmental degradation. As a result, people of CHTs are affected due to poor governance due to migration of 400,000 landless from 1979 to 1984 (IDMC, 2006)

#### *5.6.1.3 Water channels are conserved and protected*

Current situation: It is a bad news for the indigenous people of the CHT that the springs of this region are drying out. It is assumed that a hundred years back, there were as many as 200,000 springs flowing over the CHT area. Presently, there are no statistics of how many springs are still flowing. But the local people can easily understand that many springs across the CHT are dying each year (Alam, *et. al.* 2004).

#### *5.6.1.4 Degraded slopes are rehabilitated*

Current situation: Due to vast population load in degraded slope, environmental risk is increasing day by day (Field Observation).

#### *5.6.1.5 Economic-ecological gardens are constructed*

Current situation: Some NGO is working to train people to come forward for making economic-ecological gardens (Field Observation).

#### *5.6.1.6 Food, Clothes, Housing, Education and Medical facilities are ensured*

Current situation: Local people take bath by lying inside almost filled up creek. It was really horrible for a human life style. They are using same water for livestock bath, household works. As a result different water borne diseases and Malaria is one of the environmental issues identified by CHTs communities. People do not have capacity to fill up needs health treatment, so they used to use their indigenous knowledge (Field Observation and WOCAT, 2006).

#### *5.6.1.7 Maximum utilization of manpower*

Current situation: Manpower is trying utilized by developing organization but it is very tough for them to work with the local people due to their different traditions, cultures and languages (Field Observation).

## **Principle 6: Management planning**

### **6.1 Forest Management Plan**

#### **6.1.1 Existence of Forest Management Plan**

##### ***6.1.1.1 Maps of resources, management, ownership and inventories are available***

Current situation: There are no available maps of resources, management, ownership and inventories. Increase in population and economic activities have imposed great pressure on ecologically sensitive areas from encroachment and unsustainable use. This trend is likely to continue in the absence of an integrated water and land-use management plan. Mr Giasuddin Ahmed Choudhury, Executive Director of CEGIS (Center for Environmental & Geographic Information Services), gave an overview of the geophysical environment of the CHT. He emphasized that CEGIS is already involved in various activities concerning the development of the CHT. The speaker emphasized the relevance of the capacity of CEGIS in analyzing satellite imagery for different aspects of land use management and planning. He expressed confidence in the contribution of the local stakeholders and the hope for feedback that will help to prepare and implement effective plans for resource management in the CHTs (Mantel, *et. al.* 2006).

##### ***6.1.1.2 Silvicultural systems are prescribed according to different landuse***

Current situation: Forests of Bandarban divisions have been managed under a clear felling silvicultural system, followed by artificial regeneration system through plantations of commercially important species, Teak and Gamar. Due to lack of fund, plantations could not be raised on all clear-felled forest areas (FSP, 2003), but the recommended silvicultural system is the management of degraded Bandarban forest through “Selection-cum-improvement” system.

##### ***6.1.1.3 Yield regulation by area and/or volume is prescribed in management plan***

Current situation: The working plan was produced during the British period. The recommendations made in the feasibility studies of managing the hill forest at a rotation of 40 years (Field Observation and discussion).

##### ***6.1.1.4 Harvesting systems and equipment are prescribed to match forest conditions in order to reduce impact.***

Current situation: According to Participatory Management Plan for Bandarban and Lama forest divisions under Forestry Sector Project, there are some rules for harvesting. General people do not know about the rules. People use hand saw to harvest the tree without following harvesting system (Field Observation).

##### ***6.1.1.5 Objectives are clearly stated in terms of the major functions of the forest, with due respect to their spatial distribution in a map or in the management plan***

Current situation: No, there is no forest management plan. Many functions of natural forest like springs of CHT have not come forth from the melted ice or glaciers as it normally happens in many parts of the world. The springs of the Chittagong Hill Tracts have originated from the drops of water discharged through the tree roots accumulating in the cleft of the hills. However, the sweating of the hills and precipitation reinforces the process. Of course, this wonderful process of spring creation happens only on those hills where cover of indigenous forests is thick. But the indigenous forests in CHT are depleting gradually due to the over growth of population and

injudicious development initiatives of the governments and development agencies (Alam, *et. al.* 2004).

#### *6.1.1.6 Immature Extension Services are able to convince people.*

Current situation: Afforestation extension is successful as people are more aware to plant fruit, timber species around their home through arranging annual tree fair, distributing seedlings. Different NGO is successful to motivate the people like people are more conscious to send their child to school, conscious about using sanitary latrine. But there is no activity for regulating natural resource conservation (Field Observation).

#### *6.1.1.7 Peoples participation and co-operation is significant not only to find out solution but also implement the management strategies*

Current situation: The objective of the CHARM project is to contribute to improve NRM in the CHT through provision of improved access to knowledge and information about the environment and sustainable land management alternatives (Mantel, *et. al.* 2006)

### **6.1.2 Utilization of Skilled Manpower and professional foresters and environmentalist**

#### *6.1.2.1 Experienced persons are responsible for sustainable implementation of forest management plan.*

Current situation: Management plan is so general for all areas. As land use are different in different parts of the country. Responsible Forestry professionals from site specific area should be involved for preparing site-specific forest management plan. It is very pity that Chittagong Hill Tracts has no Forest Management Plan (Field Observation and discussion).

#### *6.1.2.2 Appropriate planning tools and instruments are present*

Current situation: Now, WOCAT, SRDI, BFRI, CEGIS are trying to develop some software like GIS-Bangladesh Country Almanac (Field Observation and discussion).

## **6.3 Evaluation and Monitoring**

### **6.3.1 Inventories are done**

#### *6.3.1.1 Evaluation and Monitoring Authority are active*

Current situation: CARITAS has very strong "Evaluation and Monitoring Authority"(Field Observation and discussion).

#### *6.3.1.2 Monitoring activity is systematic, strict and appropriate*

Current situation: Very technical, strict, and appropriate monitoring activities are necessary to control the risk of existing situation (Field Observation and discussion).

#### *6.3.1.3 Responsible Authority is conscious*

Current situation: Some NGO is very responsible for documentation of their each and activities, but documentation is totally absent in Government level (Field Observation and discussion).

#### *6.3.1.4 Use of property by the local people are sustainable*

Current situation: Property use is not sustainable by the local people. The reality is that no rules and regulations and system will work till the alternate way of providing daily food and other needs (Field Observation and discussion).

#### *6.3.1.5 Immediate actions are necessary*

Current situation: Inventories are essential to carry out to realize the real situation properly as various funds of International, national and foreign funds are allocated for the Chittagong hill tracts people (Field Observation and discussion).

### **6.3.2 Report is written and recommendations are used for restructuring revision of management framework**

#### *6.3.2.1 Management planning is started at the local level*

Current situation: Now a day, few project works by, ICIMOD, WAB, UNDP and CARITAS are trying to train local people from different tribal community so that they can work as a Village community leader. Activities should be more extensive (ICIMOD, 2003; Field Observation and discussion).

#### *6.3.2.2 Reports are prepared on “Awareness of people are increased to participate in afforestation activity”*

Current situation: Society for Environment and Human Development (SEHD), founded in 1993, is a registered Bangladeshi non-profit organization engaged in action-oriented research, investigative reporting, documentation, training and advocacy on issues concerning environment, human rights and indigenous peoples (SEHD web source)

#### *6.3.2.3 Reports are prepared on “Homestead Forests are expanded”*

Current situation: Many research reports are available about “Homestead Forest”, e.g., Productive Homestead Gardening by CHTDB (Field Observation and discussion)

#### *6.3.2.4 Report is prepared on “Bio-energy powers are introduced to meet fuelwood demand.”*

Current situation: LGED (Local Government Engineering Department) for “Green Energy Programme under sustainable rural energy” explored some opportunities for community based renewable energy options for different applications and use, e.g., Small Hydro-possibilities in Bangladesh and Bio-mass Technology promotion. Those activities are well documented, published in different journals and available in internet (Field Observation and discussion).

#### *6.3.2.5 Report is prepared on “Experts are involved to find out new strategies for poor forest dependent communities”*

Current situation: There are lots of conservation technologies documented in different journals, books published from different research organization as a report. But those reports are not transferred at the global level (Field Observation and discussion).

*6.3.2.6 Reports are prepared on “Women are contributing in the Natural resource management.”*

Current situation: There is no direct report on women contribution in natural resource management. For example, Women contribution in homestead forest is significant although homestead forests are the responsibility of the entire family (Achmad, *et al.* 1980). There is a clear sharing of tasks between women and men for the management of homestead forest and other farm activities. Especially women look after the homestead forest (Mustafa, 1996; Khan, 2002).

## 4.2 Preferences of criteria and indicators for IWRM

Criteria and indicator frameworks are tried to develop for Integrated Water Resource Management Framework at international to local scales planning at Chittagong hill tracts.

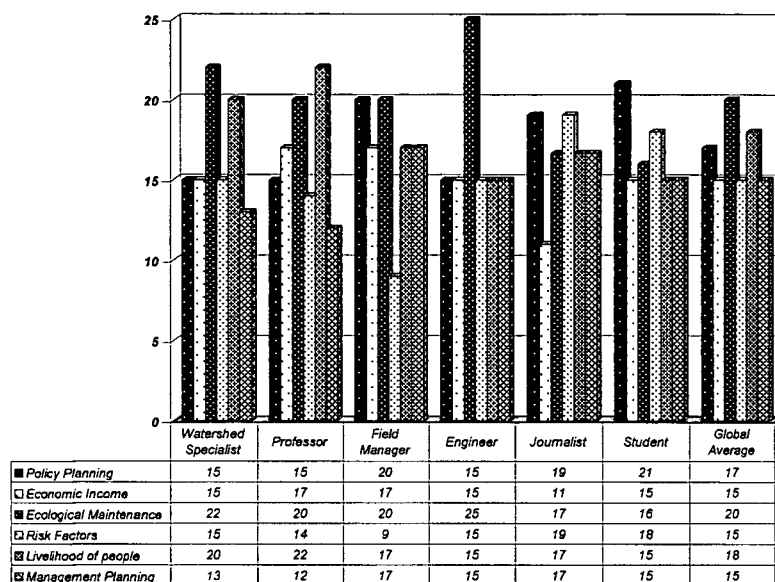


Fig – 4.1: Comparing the key informant's preferences at principal level for IWRM Framework from face to face preference elicitation

Average value preferences by six key informants; is the highest for principle “Ecological Maintenance”. Student and field manager gave the highest preferences for policy planning, where watershed specialist, professor and Engineer have similar preferences for policy planning.

### 4.2.1 Comparing the key informant's preferences for Policy planning in the IWRM Framework

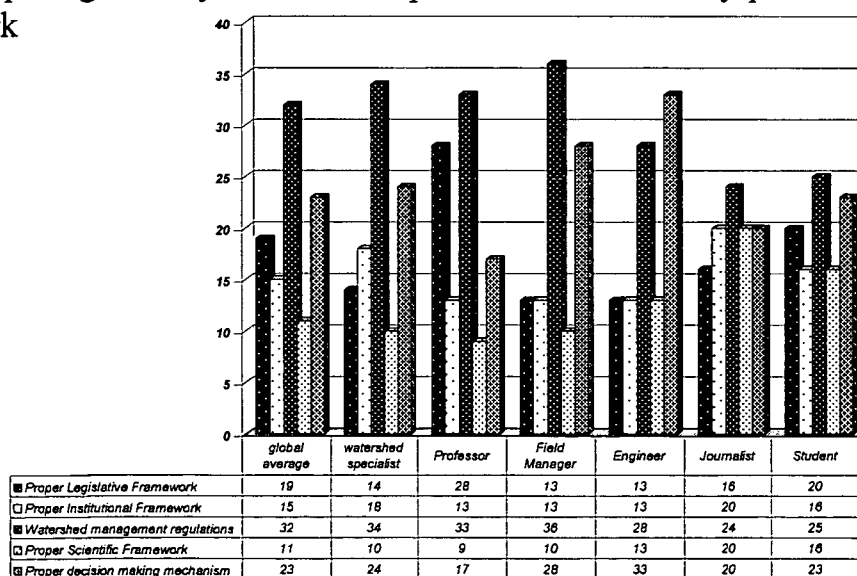


Fig – 4.2: Comparing the key informant's preferences at criteria level for Policy planning of IWRM Framework from face to face preference elicitation

Watershed management regulations were highly preferable according global average value as well as for all stakeholder preferences for policy planning to fulfill the goal of IWRM. Decision making mechanism is the best preferable criteria to Engineer comparing with other key informants where as professors proposed significantly high preferences for legislative framework, medium preferences by students, and almost similar and lower preferences by Field managers, watershed specialist, journal and students; Journalist gave highest preferences for Proper Institutional Framework than other key informants The criteria of scientific framework preferences are highly preferred by Journalist and lowest value given by professors comparatively. In general, Watershed management regulations is highly preferred than other four criteria where as Proper scientific are less preferable by five informants framework except journalist who gave highest preferences. Journalist chose almost equal preferences for all criteria. (Fig: 4.2)

#### 4.2.2 Preference analysis of Key informants for Economic Income

Net income of farmer is more significant than income generation for state as average preferences of key informants. Field manager and Engineer prefer contribution of farmers and income generation for estate equally for economic income. Both students and professors preferences are equal for income generation for state whereas watershed specialist and engineer gave equal preferences (Fig: 4.3)

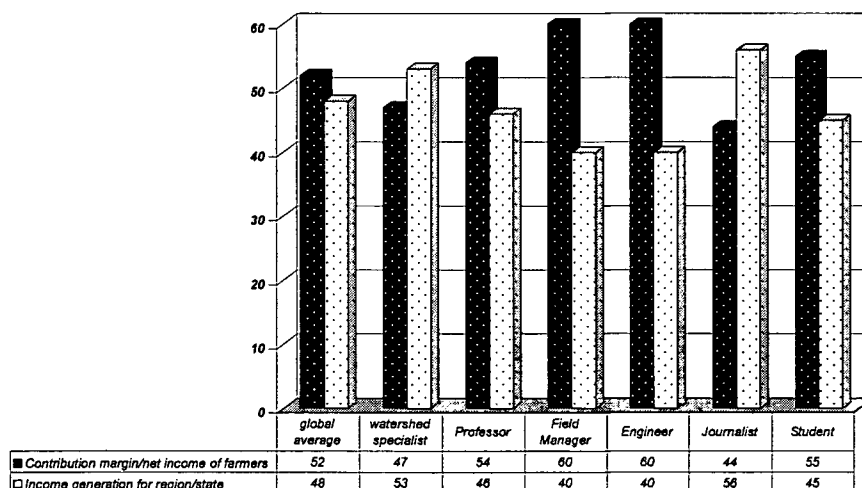


Fig – 4.3: Comparing the key informant's preferences at criteria level for Economic Income of IWRM Framework from face to face preference elicitation

#### 4.2.3 Preference analysis of Key informants for Ecological Maintenance

Biodiversity maintenance was the highest average preferences and degraded site identification was the lowest average preferences for ecological maintenance. Field manager gave the highest preferences for the maintenance of water quality for IWRM where other five gave almost similar preferences. Soil fertility maintenance was equally preferable to all informants (Fig: 4.4)

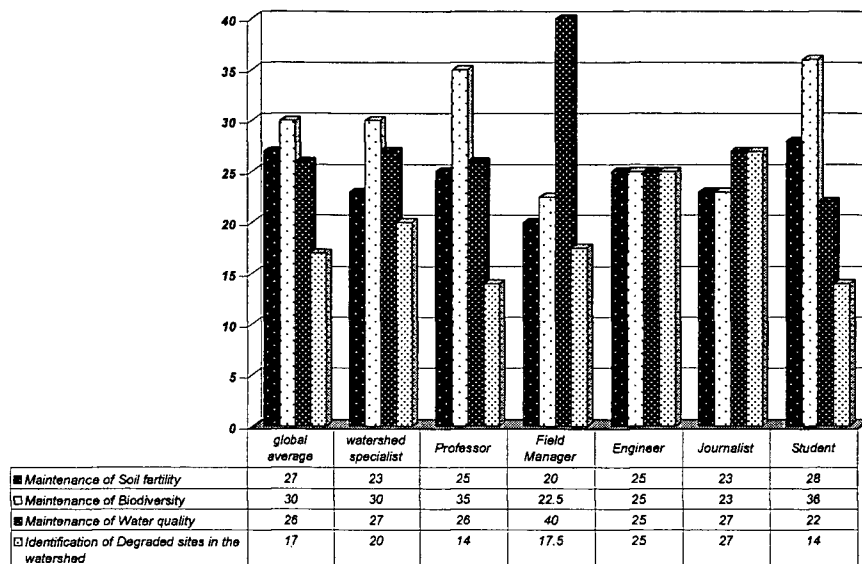


Fig – 4.4: Comparing the key informant's preferences at criteria level for Ecological Maintenance of IWRM Framework from face to face preference elicitation

#### 4.2.4 Preference analysis of Key informants for Risk Factors

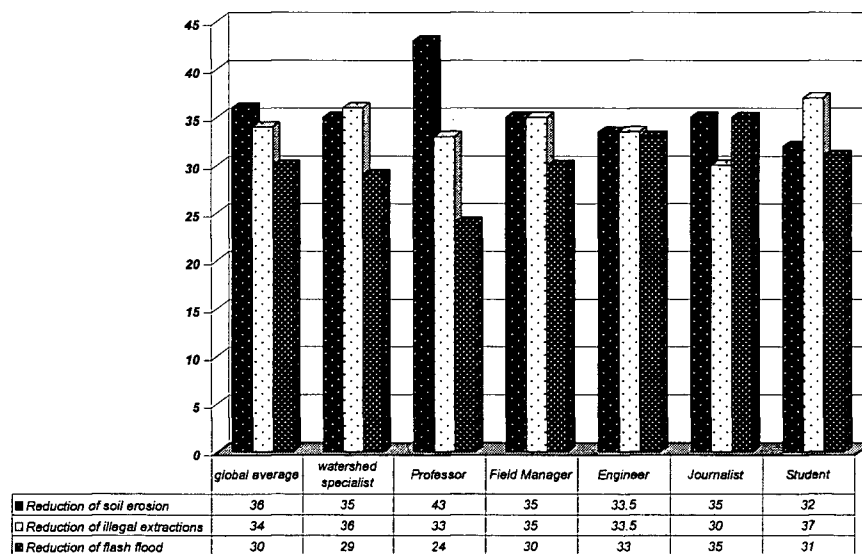


Fig - 4.5: Comparing the key informant's preferences at criteria level for Risk Factors of IWRM Framework from face to face preference elicitation

Soil Erosion reduction was the average highest preferences and preferences of professor for reduction of soil erosion was significantly higher than other key informants. Reduction of illegal extraction was almost equally preferable to all key informants. Journalist gave highest value for reduction of flash flood where as other informants gave less value than two criteria for risk factors (Fig - 4.5)

#### 4.2.5 Preference analysis of Key informants for livelihood of people

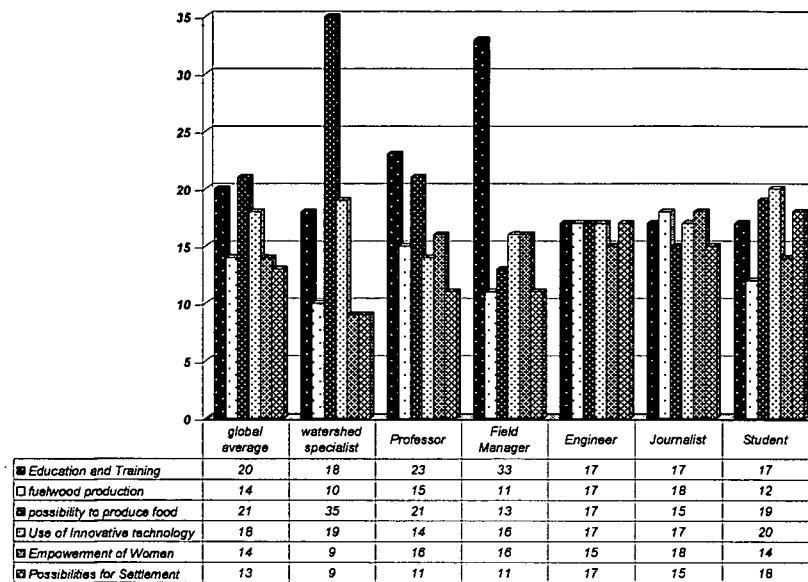


Fig – 4.6: Comparing the key informant's preferences at criteria level for livelihood of

People of IWRM Framework gave opinion from face to face preference elicitation. Average high preference of all key informants is the criteria of possibility to produce food and low preference is possibility of settlement. Comparing with other criteria and stakeholder, watershed specialist gave significantly highest preferences for possibility of food production. According to field manager, education and training is highly significant than other criteria. Innovative technology use were equally preferable to informants (Fig – 4.6)

#### 4.2.6 Preference analysis of Key informants for Management Planning

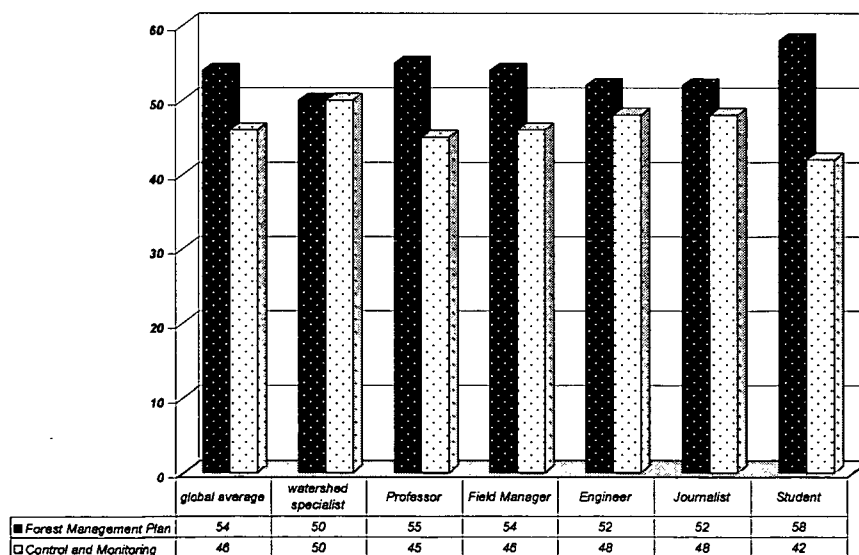


Fig – 4.7: Comparing the key informant's preferences at criteria level for Management Planning of IWRM Framework from face to face preference elicitation

Forest management plan is the highest preferable to students, lowest preferable to Watershed specialist. Control and monitoring is highly preferred to groups of watershed specialist and equally preferable to groups of professor, field manager, Engineer and Journalists (Fig - 4.7).

### **4.3 Development of management alternatives**

Management alternatives are developed to fulfill every key components of Integrated Water Resource Management (IWRM) considering the developed PCIV set and current situation of the study area in the Chittagong hill tracts. 46 different activities are developed to improve standard policy, economy, ecosystem, risk factors, livelihood standard of people and management planning of planned “Integrated Water Resource Management Framework” for Chittagong hill tracts. Background information from web sources, field research experiences and continuous discussions with local experts and systematic guidelines of Professor Harald Vacik, six different alternative management strategies for IWRM in Chittagong hill tracts have been formulated

#### **4.3.1 Possible activities for IWRM**

Necessary activities for IWRM are developed according to CIV set assessment and based on the evaluation of the current situation and the proposed activities in the CHTs (compare 3.5.2.1). The following activities can be beneficial.

- 1) Intensive research works are applied to produce good data and information about the status of bio-diversity. In addition, these activities are helpful to identify the problems of degrading bio-diversity for Ecological Maintenance of the “Watershed Area” as well as discover the biologically rich sites.
- 2) Experimented conservation technologies are conveyed to the field experienced local representatives as well as creating awareness of implementing new conservation approaches.
- 3) Advanced research and innovation is trying to find Participatory Innovation Development for “Bio-diversity Conservation” through “Community benefit sharing” and utilizing the preference of the participants regarding the choice of species, locations of plantations, marketing of forest products and services.
- 4) Management and Conservation of Rich Biological site are essential for ecological maintenance. Rich Bio-diversified sites are managed for supplying enough seed, ensuring buffer zone of soil-erosion and providing food and shelter for wild life. For example, the edge of the water catchments area and the sides of the creeks are conserved and planted with soil binding leguminous species and locally preferable species that are managed as buffer zone. If buffer zone is maintained for 20 years, some facilities like free health insurance and free medicine are provided in the hospital. The buffer zone may be 0.5 ha or 1 ha or more. As participants in buffer zone management, they get more facility or some additional money for conserving hill ecosystem.
- 5) Demand of local people for livelihood security are identified for upgrading the status of Livelihood of people, afterwards those information are utilized for Policy planning and implementing practical work for management. For example, Natural resource manager are employed. His or her responsibility is to find out the skilled and interested people with whom planned activities are successfully managed for IWRM. People who are engaged in nursery management, plantation, problem of getting available high productive seedling and seeds are solved. Government is obliged to fulfill the requirement of seeds and seedlings of nursery

manager. In addition, poor people who want to be self dependent through establishing a forest with other off farm activities, he is provided with high subsidies for joining the activities.

6) Local people participation in natural resource management is assured. For example,

Politicians, actors and musicians are invited during village fair through arranging shops of seeds and seedlings and by making awareness songs for participating in the activities of natural resource management for saving the degraded environment. As people are very emotional, local people are participated in different training like Rice-shrimp farm, plant nursery, Eco-village, Environmental school, pond re-excavation for drinking, pond re-excavation for fish culture, sanitary latrine installation, highly productive vegetable seed production. Afterwards, skilled and interested manpower are selected for restoration, protection and conservation of the selected area.

7) Decision making mechanism is maintained through diverse set of stakeholders for perfect policy planning. Field manager of environmental NGO, Religious organization, Forest manager and researcher from Government, upazila administrator, and local committee are invited at discussion to derive the best solution for protecting the bio-physical environment of fragile ecosystem in Chittagong hill tracts. Discussion may produce new alternatives to tackle the problems of water and food scarcity through systematic utilization of available natural resources sustainably. Difficult problems are solved with the co-operation of global scientist group by making easy accessible information about problems, scopes, facilities, progress and recent activities. Working experiences of developing organization and Research professionals are documented and utilized. Discussion and participation of stakeholders are organized and maintained in a framework among national, regional and local authorities sharing opinions to fulfill the demand and problems. Users' responsibilities are awarded to make encouragement to other for following the activities.

8) Bio-diversity zone, Flood control zone, Soil and water quality conservation zone, Indigenous Knowledge Conservation zone, Self income generating conservation zone and Landscape Management zone, are demarcated in a map. Specific silvicultural prescription for each zone is prescribed according to demands and for maximum utilization of surrounding components.

9) Rules and regulations are strictly maintained for maintaining proper legal framework. Local institutions are active for the assurance of Ownership rights, maintenance of local people awareness and motivation about their right and managing natural resources. Political parties support and contribute for making awareness that are very necessary for implementing strong law enforcement. Intensive restriction and management is regulated in certain area, like rich biodiversity site are accessed by people through creating Eco-park, but people who pollute, he or she is bound to pay or arrested by police according to meet the demand of IWRM

10) Management Report for proper management planning is obligatory after six month or annually. Annual report submission is bounded by the Government with law for evaluating and monitoring of Management plan. Responsible forest managers, engineers, scientists and administrators provide the report about the activities, problems and experiences during management and implementation output rate. For example, illegal extraction of resources are reported and handled through assessing the demands of timber, encouraging mass plantation programme, providing punishment of illegal extractor and involving local people for handling the illegal extractor

11) Special Training of Flood Management for Responsible managers in flood prone area and increasing local people's coping capacity for reducing risks. Professionals like forest managers,

project managers, and field managers are trained with a comprehensive understanding of the geologic settings of the region, and a better knowledge of hydrodynamic processes that are active in watersheds. People's coping capacity is increased and build up by emergency forecasting, Warning, Evacuation, Compensation, Insurance and Drainage system.

12) Best Management practices are formulated for reducing risk. Workshops are arranged to formulate "Best Management Practices" for reducing the scale of floods in association with diverse professionals like geologists, Engineer, Foresters, Lawyers, Civil Society. Flood Zoning and Risk Mapping (FZRM) are done and local government institutions are efficient and active to handle the risk

13) Floodplain Management is immediately implemented for commensurating the existing risk. Emphasized features and activities are: dredging of rivers, re-excavation of abandoned channels-ponds-lakes, utilization of dredged sediments to increase village platforms and road elevations, conservation of tillage, establishment of forest buffer zone along rivers, putting silt fences around construction sites, building sediment retention ponds in construction sites, efficient storm sewer systems, planned urbanization, watershed-scale land use zoning maps, reforestation and good governance. Floodplain management are implemented by considering, better catchment management, controlling runoff, detention basins, dams protecting wetlands, isolating the threat of floods, flood embankments, flood proofing, limiting floodplain development through ensuring participation from India, Nepal, and Bhutan for sharing of national, regional and local authorities of multi-sectoral co-operation among organizations and Governments.

14) High subsidies are arranged for engaging people in natural resource management for combating environmental degradation. Poor people are provided with highly subsidies for changing the attitude of neglecting the protection and management of the forest cover in watersheds. Monitoring is obvious how subsidies are utilizing for doing alternative income generation works like training on nursery management for medicinal plants, vocational and trade training on tailoring, embroidery, training for awareness build up, leadership management, Account management for participants. Institutions are responsible for arranging commercial trade and marketing of products.

15) Interactive approaches between researcher and farmer are created for implementing sustainable activities for proper decision making mechanism where farmers and researchers work together and that may be attempted to provide bridges between different worlds of understanding, link scientists' understandings with farmers' insights by organizing workshops and joint experimentation. Afterwards an innovation approach may be discovered for sustainable and maximum utilization of natural resources. Moreover, the problems of extrapolation from limited data sets are possible to overcome complex social, cultural or economic contexts.

16) Priority risk area is identified, protected and conserved. Most risk and threatened watershed areas are taken into consideration for immediate action For example, protection and/or reforestation of uncultivated upper watershed areas are taken into action firstly for overall watershed management. Protection of soil loss and sloping land management are dealt with advanced research and technology through replacing traditional jhum cultivation technically by adopting ghona farming systems and marking threatened landslides. Settlement are planned and organized without harnessing environment. Government is conscious for natural resource management of the re-settlement area and assessing carrying capacity of the area

17) Soil fertility and nutrient management are started by the identification of: biological, physical and chemical deterioration of these soils through the assistance of skilled scientists, farmers,

researcher and students of forestry professionals (Scientific framework). Identified causes for deterioration are trying to solve through immediate actions by decision making groups. For example, Forest along the water catchment area are conserved and managed through distributing free plantation materials and utilizing innovative technologies. In addition, homestead on hills are encouraged to plant tree species in vacant places and they are provided with some facilities like free health treatment and medicine for children and free transportation. Moreover, Hill cutting is controlled by legal framework during soil collection for infrastructure building

18) Water quality and quantity are maintained so that water cannot be polluted from roadsides, footpaths, breakthroughs, livestock production, grazing lands, village life, and landslides in the landscape. Intensive attentions are focused dealing with severe water crisis by following an innovative practice of sloping land use like systematic water harvesting in the foot slopes of the hill for multipurpose use for fishery, duck farming and irrigation of rice field. Additional actions may be highlighted to meet through sustainable natural resource management, conservation and protection of environmental health,

19) Bio-engineering knowledge is applied for environmentally sound construction. Blocked or threatened water reservoir are urgently cleaned and managed through bio-technology measures like soil binding tree species are planted around the edge of the pond for fish production and catchment capacity is increased. Cross dams, drains, compartments require to construct to keep the water flow management.

20) Multi-sectoral organizations are strongly interacted among proper decision making mechanism. Development agents (NGOs, governments, donors, local leaders, and private sector initiatives) are identified and indigenous knowledge of local people is recognized, valued and documented through close interaction with the local communities.

Preliminary Survey is done in the project area to know the scopes, possibilities and interest of the local people about the idea of indigenous knowledge. Afterwards, local NGOs scientists, religious organization, environmentalists are invited for discussion to formulate the planning how best collection of Indigenous knowledge is possible.

21) Local conservation strategy is recognized as farmers in the CHT have traditionally grown a range of tree crops and have integrated these into their shifting cultivation. Communication and extension services are responsible to identify the local conservation strategies of local people. NGO's consultants and experienced field manager are discussed and assessed about the importance of ITK based on the survey and the best management practices may discovered from local indigenous knowledge.

22) Sufficient raw materials are available to meet the demand of commercial and local purposes like pharmacy, herbal aromatics etc. For example, Medicinal plant reserves are conserved and ethnic values are preserved. Rich genetic pool of NTFP like medicinal plant and other indigenous species are possible to conserve. In this way, potential Indigenous knowledge of local experiences are not only utilized and valued, but also tackle the problem of disappearances of indigenous knowledge in future.

23) Indigenous knowledge systems are practiced through conventional approaches by which sustainable gains are usual instead of achieving promising short-term gains or solutions to problems. Rational conclusions are based on determining whether indigenous knowledge would contribute to solve existing problems and achieving the intended objectives.

24) Careful amalgamation of indigenous knowledge and advanced technological knowledge, are most promising, to meet up the rate and the degree of adaptation to the target groups. Planners and implementers are responsible to decide which path to follow.

25) People are convinced that indigenous practices are developed to be adopted faster and applied more successfully. For example, Sustainable traditional water management is conserved.

26) A sound understanding of indigenous knowledge is needed to foster exchange knowledge between different stakeholders at international level

27) Ecologically sensitive areas are identified as the population of wild life was seriously affected due to population pressure and destruction of environment for livelihood of the newly migrated population and the displaced indigenous peoples as well as massive illegal logging.

Precautionary and protective measures are well defined by adopting and exercising watershed-scale best management practices by scientists. Each component of watershed-scale best management practices is clearly defined. Exchange of technology and expertise knowledge are ensured to responsible developing organization and local people. Local people are free to express their opinion, demand and problems so that international, technical and scientific co-operations are promoted

28) Restoration and protection of potential sites e.g., Ecosystem of watershed area for reducing risks. Watershed are managed to maintain a healthy, productive landscape rather than humanitarian efforts for the poor on marginal potential hillsides. Potential restoration of site is focused site rather than the poverty. Growth potential of forest is strictly maintained by planting native species for maintaining soil nutrient balance in the area.

29) Participatory research action are ensured through mobilization of problems of local resource. The strong Co-operation of Hill District Council helps decision makers for analyzing decision problems through discussion with different stakeholders involved in these activities. A strong policy is possible to formulate through local People's and stakeholder's participation, communication and co-operation. So beneficiaries feel to take part in decision-making and are committed to be present on time in participatory planning meetings

30) Selected activities are promoted that are preventive rather than curative for reducing desired risk. For example, many species of flora and fauna are red listed by IUCN. So it is very essential to find the cause why they are going to be endangered and needs special attention for conservation of those species.

31) Current activities are best accelerated and expanded through forming local enterprises with some rules and regulation for environmental conservation. As a result, local level communications are expanded for participation IWRM activities.

32) Natural resource degradation is decreased through active involvement of people in Watershed wise management projects. Skilled of Human Resources are utilized through providing loans effectively according to the situation demand.

33) Proper Scientific Framework is maintained through increasing skilled scientific research capacities, identifying research relevant to IWRM. In addition, positive and negative research results are conveyed to field experienced local representative to inform local people about the necessity of IWRM

34) The people who are selected for operating the activities, their knowledge and skill are very important to fulfill the target of income generation and conservation at a time. So, skilled and

interested people are preferred for fulfilling the target of IWRM. Training is provided for implementation of the activities if it is essential. After 7 year successful management, people are provided with watershed certificate that carry some facilities like free medicine in the hospital, free seedlings from nursery etc. Women are highly encouraged to be a watershed conservationist.

35) Most limiting factor for management is identified. The management is regulated in such a way that it is not a choice between people or trees/soils, or even benefiting upstream or downstream dwellers; but it is rather a challenge of identifying the most critical limiting factors and the best powerful points to achieve both economic development and long-term management of natural resources.

36) Conservation of natural resources is cost-effective and long lasting on the basis of land use capacity and income-generating potential, for example, commercial fruit production (e.g. Pine-apple, Jackfruit, Lemon Guava, Orange, Banana, Papaya and other) are ensured through ensuring sufficient highly productive seeds, scientifically management of nursery, and arranging marketing facilities

37) Adequate monitoring of restoration system is focused on restoring ecosystem processes of watershed. It requires comprehensive data base about ongoing activities and output of the activity For example, record all activities and problem facing to expand forest cover in a deforested and degraded area For example, restoring soil, air and water of an ecosystem requires regular and continuous inspection to check availability, cost and marketing of seedlings in nursery, how much seedlings are using for plantations in a month.

38) Local people are self-motivated to use the strategy as implementing authority are very respectful to traditional norms and beliefs of those people.

39) Motivation of people is done for creating awareness among newly settled people from other places who are unemployed and they are obliged to join IWRM activities. Threats to the landscape are focused and cost-effectiveness of the investment are ensured for motivating ethnic people where landscape and Economic improvement is self-evident; In addition, there are different alternatives like providing some loans for small scale business for making money with conservation of landscape. For example, Small scale enterprises are established through developing enterprises for weaving, cane and bamboo works, poultry, so that some job facilities are available and some illiterate and poor people are self dependent

40) Community and land owner are actively participated for regulating the activities. Landscape management is simple, easily replicable, low cost farming system of hill considering the carrying capacity of the topography and capability of hill sloping lands. Awareness raising is done through providing appropriate incentives for other off-farm activities like Piggery, Poultry rearing Apiculture Mushroom cultivation New weaving design etc. incorporating with sustainable management of threatened watershed .Livelihood status is possible to upgrade through adequate extraction of products from watershed area.

41) Training is arranged for landscape management that helps people to realize how these activities develop their skill to save environment and their livelihood at a time. Also, training is provided for making money through making handicrafts, sericulture, tourism, agricultural instruments, food, religious, musical instruments involving activities on natural resource conservation. As a result illegal encroachments are decreased and natural resources are utilized to produce income for people. Compliances of international protocol are maintained for natural resource conservation.

42) Beneficiaries facilities are clearly explained and defined before joining to the activities. Proper Institutional Framework is maintained through strengthening multi-level institution. Time and Patience are ensured within institutions to reach the goal of IWRM. Institutions are bound to be active to increase the effectiveness through forming village leadership committee. The Institution is willing to listen to the Grassroots that are influenced and benefited from different activities of the institution. Community is hard working to organize themselves to be self-dependent and beneficiaries are discharging their responsibility

43) Diverse types of landscape in Watershed are conserved following different landscape conservation strategy for different objectives of management like some areas are reserved for maintenance of recreation and aesthetic values and access of tourism facilities.

44) Protection forests are maintained and managed for protection of soil erosion, control and efficient use of water for irrigation to biodiversity enhancement, afterwards which may bring more improvements in the watershed management.

45) Efficient use of water for irrigation is possible through mulching that moderates soil temperature, thus promoting greater root development and conserves moisture by reducing evaporation of water vapor from the soil surface. This reduces water requirements. Mulching prevents compaction by reducing soil crusting during natural rainfall or irrigation.

46) Maintenance of report of each and every task are carefully documented, monitored and evaluated annually. There are strict responsibilities of forest managers to maintain documents how much production is decreasing or increasing per year by involving local farmers, who can help to make documentation of annual production of land, or responsible developing organization may prepare the report.

#### 4.3.2 Descriptions of Management strategies

##### **MS-I: Bio-diversity Conservation Strategy**

###### Activities according to policy planning

Legal framework may help to ensure ownership right of land for people through training on land issues and related laws for giving basic legal awareness; arranging workshop within community leaders, forming advocacy team, lobbying and networking team. As the culture and language of the local people of the study area are different, only local level institutions may serve the role of convincing the necessity of bio-diversity conservation with the help of multi-level institutions. Intensive research works helps to identify existing resources, problems and well defined precautionary and protective measures. Related stakeholders are free for giving equal power to express the opinion of people that leads to create a link and awareness about IWRM among different groups. Afterwards this approach helps to set up watershed certifications for effective land management with the help of political awareness. In detail the activities 1, 10, 9, 7, 29, 31, 33 are applied (compare annex) and the following set on C&I and verifiers will be influenced 1.3, 1.4, 1.1.1, 1.1.2, 1.5, 1.2.1.1, 1.2.1.6.

###### Activities according to Economic Income

Interested persons are selected as bio-diversity conservationists. According to the performance, sufficient local incentives are provided for raising awareness to join the established Eco-village and manage the threatened watershed; re-excavation pond for drinking and fish culture, plantation growing along the edge of the ponds. Villagers are earning money from different off farm activities like fish cultivation, vegetable gardening, Bee keeping, cotton cultivation, crab culture, nursery establishment. International agreements (like Dublin agreement on IWRM on

1992, CBD agreement) are maintained and alternative ways of income generation are applied by biodiversity conservation activities. In detail the activities 6, 23, 25, 26, 34 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 2.1, 2.2.

#### Activities for Ecological maintenance

As rich bio-diversified sites are discovered through intensive research work and those areas are protected and conserved as hotspots of Bio-diversity for protecting restoring and recovering mountain ecosystem. Maximum utilization of resources is possible through land use classification system after demarcating the area into different zone for different management purposes like Bio-diversity zone, Flood control zone, Soil and water quality conservation zone, Indigenous knowledge conservation zone, self income generating conservation zone and Landscape management zone. Blocked water catchment areas are cleaned and managed for fish cultivation. The edge of the water resources are utilized for growing forest species. Threatened watersheds are immediately managed as protected forest by reforesting the hilly area. People are aware about the impact of traditional hill farming system and they are convinced for following the activity of conserving local medicinal herbs, shrubs, raising plantation on vacant places and , doing rain water harvesting for maintaining soil fertility, sustainable biodiversity management, water quality maintenance. Afterwards, Monitoring and evaluation are done to check restoration of basic watershed ecosystem through bio-diversity conservation. Key threats like floods, water logging, storms, landslides and water scarcity are reduced to a some extent. In detail, the activities 4, 8, 27, 28, 43 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 3.1, 3.2, 3.3, and 3.4

#### Activities according to reduce Risk Factors

Conservation of water catchment area through bio-diversity management may reduce the risk of getting blocked and unused water reservoir. As a consequence, flash flood will be naturally reduced day by day. But this strategy is not possible to regulate over the whole area, so reduction of soil erosion may not be quietly possible immediately. While local people are participating for conserving the bio-diversity of the forest, i hope, they will handle and report the illegal extraction of timber. In detail the activities 14, 15, 18 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 4.1.1, 4.3, 4.2.1, 4.2.2.1.

#### Activities for the Livelihood of people

As we need immediate action for bio-diversity conservation, so training is given for interested people especially women through demonstration activities like Plant nursery, Eco-village, Environmental school, sapling distribution, weaving design, cane and bamboo works directly in the field by local forest manager. Trained people are obliged to conserve anyone zone of bio-diversity zone. Natural resource manager are responsible for listening the problems of farmers, monitoring the performance of the farmers and reporting the progress for discussion later on. People who have their own land, they are encouraged for homestead bio-diversity management on the hill. So, it is expected that they will participate in bio-diversity conservation activities if we assure their daily food, medicine, schooling of children etc. People from other parts of the region migrated in Chittagong hill tract. They may be obliged for participating conservation activities. I would like to suggest the building with bamboo infrastructure if it is necessary or we can meet any home of conservationists for discussions. In detail the activities 2, 3, 5, 6, 19, 31 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 5.2.1, 5.3.2, 5.1.2, 5.3.1, 5.5, 5.6.1.7, 5.4.1.2

#### Activities for Management planning

Collaborative plan are done covering all components like resource planning, people participation, extension services. Annual documentation and reporting helps to realize the existing situation, response, acceptance and consequences of the management system itself. In detail the activities

21 or 12 or 17, 10, 46 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 6.1.1.1, 6.1.1.6

## **MS-II: Flood Control Strategy**

### Activities according to policy planning

MS-II does not have any influence on legal framework. Local level institutions has strong influence to manage fund for dredging of rivers, re-excavation of abandoned channels-ponds-lakes, utilization of dredged sediments to increase village platforms and road elevations. Moreover, institutions ensure forecasting and early warning of flood and also transfer people in a safe place immediately. Village leadership committee may play important role to extend the message of the risk of flood from the institution to local people. Conscious people who have wish to clean their abandoned catchment area for utilizing for fish cultivation; they are free to do the action. Watershed management group like soil scientists, researchers and specialists on flood management are aware to arrange special training of flood management for creating special task force. Special task force maintains the linkage of institutions and responsible managers in flood prone area may lead to decrease the intensity of the risk of flood. Watershed management regulations would be one of the options for controlling flood as a best management strategy. Best management practices like watershed management are trying to adopt and exercised instead of traditional farming system through increasing coping capacity of people against losing the capacity of water catchment. The problems of reduction of flood risk is so prominent, it does not need furthermore discussion through decision making mechanism. Immediate actions are ensured for floodplain management through flood zoning and Risk Mapping. In detail the activities 6, 7, 11, 31 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 1.3, 1.3.2, 1.3.1.2, 1.2.1.1, 1.2.1.2, 1.2.1.3, 1.2.1.4, 1.2.1.6.

### Activities according to Economic Income

Flood action measures with different off-farm activities like apiculture, horticulture, roadside plantation; may help to save from immense damage of their property agriculture field through sustainable management of watershed with the help diverse conscious and active stakeholders). Natural risks are prevented trying to formulating best management practices, ultimately managing degraded soil, forests , water ecosystem through flood control strategy, although state need large among of funding to implement this strategy instead of losing vast amount of resources and people by flooding. In detail the activities 12, 14 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 2.1.2, 2.2.1.5

### Activities for Ecological maintenance

Negative impacts of key threats like floods, water logging, intensity of storms, landslides and water scarcity are trying to be handled. Better catchment management like Controlling run off, detention basins and assurance of sharing multi-sectoral co-operation will help for less soil nutrient leaching and water reservoir are not fulfilled by eroded soil from the hill. The management activities may be like re-excavation of abandoned channels, utilization of dredged sediments to increase the village platform, reforestation that helps to create a sustainable ecosystem for conserving flora and fauna. In detail the activities 16, 30 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 3.2.1.1, 3.2.1.2, 3.2.1.3, 3.2.1.4, 3.3.5.

### Activities according to reduce Risk Factors

Flood zoning and risk mapping for formulating best management practices may help for identification of the essential protective areas. The risk of damaging agricultural crops, production of fruits will be less due to less flash flood by constructing detension basin, re-excavation of channels and ponds. Conservation tillage, reforestation along catchment management helps to maintain soil stability in the hill. In detail the activities 12, 13, 30 are

applied (compare annex) and the following set on C&I and verifiers will be influenced: 4.1.1, 4.3.1.1, 4.3.1.3

#### Activities for the Livelihood of people

Women and men are equally participating in the activities for reforestation and conservation of tillage after participating different training like Dignity of women and Gender development, plantation techniques, nursery development. Government and diverse groups of people like geologists, engineer, forester, lawyers, civil society are involved for maintaining and planning the infrastructure of settlement by ensuring protection and conservation of water channels, degraded slopes in the re-settlement area. In detail the activity 32, is applied (compare annex) and the following set on C&I and verifiers will be influenced: 5.5, 5.6.1.1, 5.6.1.3

#### Activities for Management planning

Flood control strategy is sustainably possible to maintain if forest management plan and local people correlates with the actions of Flood control strategy. Trainee managers like forest managers, natural resource managers, and project manager are responsible for making awareness among people and obliged for using training knowledge and writing report to local people perception and participation, problems and opportunities. In detail the activities 10, 34, 46, 37 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 6.1.1.6, 6.1.1.7, 6.1.2.

### **MS-III: Soil and Water quality conservation Strategy**

#### Activities according to policy planning

Local institutions are responsible to fulfill the demand of necessary seed, seedling and equipments .Soil fertility and water management requires the active participation of people through political awareness .Soil research and development institute may maintain the institutional framework with multilevel organizations through managing enough subsidies for local enterprise development with soil and water conservation measures. Scientists go to the field to talk with the field conservationists for visiting the activity, and solving the problems of the farmers directly. Watershed group may create awareness among stakeholders and local people for participating in these activities. In detail the activities 14, 15, 16 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 1.2.1.4, 1.3.3, 1.1, 1.3, 1.5.4.1, 1.3.2, 1.4.1.1, 1.4.1.2

#### Activities according to Economic Income

When interested and money lacking people will get money, they are able to establish small scale enterprises with soil and water conservation strategy. People are aware, convinced and participated in soil and water conservation. Individual's income is increased for solving their problems in management in co-operation with scientists as well as using money for other income generating activities like nursery management for medicinal plants. In detail the activities 31, 32, 34 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 2.1.1, 2.1.2.2, 2.2.1.4, 2.1.2.3, 2.2.1.5.

#### Activities for Ecological maintenance

How much biological, physical and chemical deterioration are occurring that will be identified by scientists for soil fertility and nutrient management. Conservation approaches like ghona farming system are adopted for hill farming system instead of shifting cultivation that may have excellent influence for reduction of soil erosion, Threatened landslides are marked, protected and conserved. Sustainable soil fertility and nutrient management requires for successful regeneration, and growth of forest species. Free forest seedlings are distributed on special occasion like environmental day, New year day, religious festival. Survey is done on watershed of Chittagong hill tracts. Immediate actions like bio-engineering technology are applied and later on, planning is done for potential use of watershed area. In detail the activities 2, 14, 17, 18, 19,

28 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 3.1.1.1, 3.1.1.2, 3.1.1.3, 3.1.2.1, 3.2.1.4, 3.2.1.5, 3.2.1.6, 3.3.1.1, 3.3.1.3, 3.3.2.2, 3.3.2.3

#### Activities according to reduce Risk Factors

Threatened areas are marked and immediately actions are applied for reducing soil erosion, stopping illegal encroachment. Advanced conservation technology and Innovative technologies are discovered and utilized through strong interaction between researchers and conservationists for reducing flood effects in the lower area. Plantation materials are available and cheap so that people are able to plant more tree than before. Illegal encroachment may reduce a little bit as some people will have the source of income generation. Because most of the illegal encroacher extracts wood from hill for business purpose where local people are involved as a employer and real illegal encroacher is not visible in eye. Flash flood will be reduced through protection and conservation of soil loss and sloping land and water catchment area management. In detail the activities 12, 13, 30 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 4.1.1, 4.1.3, 4.2.1.2.

#### Activities for the Livelihood of people

People are trained and skilled for soil and water quality conservation, they are capable to manage food by participating in these activities.. Interactive approach between researcher and conservationists may find different innovative technology for conserving bio-diversity, proper utilization of medicinal plants, as well as arranging systematic marketing system. Homestead may supply the demand of fuelwood as women are aware of the importance of these activities and they are very interested in homegarden management. People are awarded for making encouragement. In detail the activities 5, 6, 7, 8, 15, 36, 37,41, 42, 46 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 5.1.1.1, 5.2.1.1, 5.2.2.1, 5.1.3, 5.1.4.3, 5.3.1.3, 5.3.1.4, 5.3.2, 5.4.1, 5.4.2, 5.4.3, 5.5.1, 5.6.1.3, 5.6.1.4, 5.6.1.5, 5.6.1.6,5.6.1.7.

#### Activities for Management planning

Forest managers may play very important role for recommending suitable plantation species in soil and water conservation strategy for conservationists. Responsible managers are obliged to monitor how and what purpose money is using practically. Reporting by responsible managers is very important to know the input of the activities and performance of conservationist. In detail the activities 10, 37, 46 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 6.1.1.1, 6.1.1.5, 6.2.2.

### **MS-IV: Indigenous Knowledge conservation Strategy**

#### Activities according to policy planning

Preservation and conservation of such knowledge are strongly dealt by strong law enforcement capacity for organizing local institutional institute. Advanced research and innovation are extended and utilized for collecting and documenting Indigenous knowledge through collaboration of local institution by motivating people for natural resource management. Different local and innovative people are identified; skilled and knowledge are documented and tried to implement practically for IWRM by establishing different innovative enterprises local institutions that is helpful for easy motivation of people in IWRM. Political parties are very co-operative and committed for making aware about the importance of indigenous knowledge for natural resource management. It is very important and essential to analyze about the impacts of each idea about using indigenous knowledge within the decision making mechanism. Later on, this knowledge may be used with the combination of advanced technological knowledge for IWRM. Local NGOs scientists, religious organization, environmentalists are invited for discussion to formulate the planning how best collection of Indigenous knowledge is possible. In detail the activities 1, 2, 3, 6, 7, 21, 22, 23,24, 25, 26 are applied (compare annex) and the

following set on C&I and verifiers will be influenced: 1.1.2.1, 1.1.1.3, 1.1.3.1, 1.1.3.3, 1.1.3.4, 1.2.1.1, 1.2.1.2, 1.2.1.3, 1.2.1.4, 1.2.1.6, 1.3.2.1, 1.3.2.2, 1.3.3.3, 1.3.3.5, 1.3.3.1, 1.5.4.5, 1.5.4.6, 1.5.3.2, 1.5.3.3, 1.5.3.4, 1.5.3.5.

#### Activities according to Economic Income

The benefit of indigenous knowledge conservation is so intangible for local people that the output of these activities is rarely visible by farmers at first instance. But it is obvious that they are attracted and encouraged by other innovative and off-farm activities like weaving design, establishing medicinal plant garden in the homestead for small scale industries in combination with indigenous knowledge conservation for easy IWRM implementation. Incentives are allocated for the participants according to the performance of engagement in this conservation strategy. Nations needs to spend money for collecting this knowledge as the local people are totally different in their language, culture and tradition for preserving and utilizing indigenous knowledge that fulfill the commitment with International signed agreement. In detail the activities 14, 34, 42, 44 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 2.1.1.1, 2.1.2.1, 2.2.1.4, 2.2.1.5.

#### Activities for Ecological maintenance

Indigenous management of soil fertility may be discovered for appropriate hill farming technologies. Threatened patent right are reduced as all native medicinal plants are documented and conserved through different organizations. People are aware of potential use of indigenous knowledge and the impact of the shifting cultivation and they are involved as employed ITK collector. ITK will help for for planning of watershed management. In detail the activities 6, 14, 22, 34 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 3.1.1.3, 3.2.1.1, 3.2.1.3, 3.2.1.5, 3.2.2, 3.4.2.4

#### Activities according to reduce Risk Factors

If traditional shifting cultivation is possible to replace by other sustainable traditional system or innovative conservation approaches, soil erosion are reduced. Natural risk of losing indigenous knowledge is prevented. In detail the activities 22, 19 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 4.1. .

#### Activities for the Livelihood of people

Technical supports are available by reliable and experienced local representatives for assuring fund for implementing innovative technology and transferring ITK to the local people. People are active and conscious producing crops by adopting innovative technologies and creating nursery of medicinal plants that fulfill the demand of local, national and international needs. As women have very good knowledge of ITK as they acts as the main work force in the tribal system. High productive mother trees are discovered that may supply very good seed for making nursery and homestead plantation. Different innovative technology for water conservation, storage and farming in dry season are discovered, managed and conserved. In detail the activities 5, 6, 14, 34, 38, 44 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 5.1.1.1, 5.1.3, 5.1.4, 5.2.1.1, 5.3, 5.4.1.1, 5.4.2, 5.4.3, 5.5.2.1.

#### Activities for Management planning

Documents and report help us to analyze the effective indigenous conservation technology for watershed management. In detail the activities 10, 46 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 6.2.2.1, 6.2.1.

### **MS-V: Income generating watershed conservation Strategy**

#### Activities according to policy planning

Long-term management of natural resources requires strong co-operation by law enforcement capacity of legislative framework to identify, restore and protect ecologically sensitive area. Institutions are responsible for providing loans and giving training for expanding and accelerating

small enterprises in combination with income generating watershed management for interested and skilled persons. Responsible authority for Watershed management regulations ensure effective land use management by convincing watershed inhabitants Watershed certificate encourage people to participate in this activity. . Small scale enterprises are established and expanded for weaving, cane and bamboo works, poultry. In detail the activities 5, 6, 7, 14, 16, 20, 29, 31 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 1.1.2, 1.2.1, 1.3, 1.2.1.5.

#### Activities according to Economic Income

Some job facilities are available and some illiterate people are economically self dependent by sustainable management of threatened watershed. Spontaneous production brings highest benefit in co-operation multi-sectoral stakeholders. Cost effective and long lasting natural resource management is not only fulfilling the basic needs of people but also decreasing the intensity of illegal encroachment. In detail the activities 14, 31, 32, 36 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 2.1.1, 2.1.2, 2.2.1.1, 2.2.1.3, 2.2.1.4.

#### Activities for Ecological maintenance

Threatened ecologically sensitive areas of watershed are identified, protected and conserved through natural resource management and utilization that help to free from the problems of water scarcity, quality and quantity. It is very hard to make comments about the soil fertility as they are encouraged with local enterprises. But restoring ecological sensitive area , hopefully helps to add more nutrients in soil. Local enterprises will be charged by money with rules and regulations if they pollute the ecosystem of the environment. In detail the activities 27, 28, 46 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 3.1.1.1, 3.1.14, 3.3.1.1, 3.3.1.2, 3.3.1.3, 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.3.4, 3.4.

#### Activities according to reduce Risk Factors

Quality of soil stability is improved through maintenance of potential plantation along the water catchment area with advanced research and technology. Local people come forward for reducing illegal extraction. The occurrence of Flash flood are less after constructing culverts, development of embankment, road at flood level and excavation of canals. In detail the activities 16, 17, 18, 28, 30, 42, 45 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 4.1.1, 4.1.3, 4.2.1.4.

#### Activities for the Livelihood of people

This framework helps to train farmers about managing landscape suitable for recreation, and aesthetic value. Skilled and educated people are selected for the management as he or she can to communicate and express the existing problems and necessities with IWRM framework. Daily fuelwood are allowed to collect from the owned conserved area. Alternative way of generating income like commercial fruit production encourages them for participating in watershed management. After time onwards, there is a possibility to maintain biodiversity, restore of watershed ecosystem. Women share their experience for improving the management system from their experience. Some restrictions planning on settlement in ecologically sensitive area are followed by participants. In detail the activities 5, 6, 14, 16, 27 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 5.1.1.1, 5.1.3, 5.2, 5.3, 5.4, 5.5, 5.6.

#### Activities for Management planning

Documents are available about the activities of protecting and conserving Forest Ecosystem that leads to improve the wrong activities and to realize how the performance of this strategy for income generation and watershed conservation are suitable for achieving the goal of Integrated Water resource management. In detail the activities 10, 46 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 6.1.1, 6.1.2, 6.2.1.

## **MS-VI: Landscape conservation Strategy**

### **Activities according to policy planning**

Protection forests are maintained and conserved as different nice conservation strategies for creating recreation facilities and aesthetic values through ensuring ownership through legal framework. Institutions try to organize the community through forming village leader for landscape management. Village leader play the role of organizing people participation in this activity. Scientists ensure the international, technical and scientific needs of the conservationists. They are responsible for providing training on landscape conservation strategy. Fund and facilities are ensured and clearly defined. In detail the activities 5, 6, 7, 41 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 1.1.1, 1.1.2, 1.2.1, 1.3.1.3, 1.3.1.4, 1.3.2, 1.3.3.2, 1.3.3.4, 1.3.3.5, 1.3.3.7.

### **Activities according to Economic Income**

Threats to the landscape are focused and cost-effectiveness of the investment are ensured where landscape and Economic improvement will be self-evident; Training on managing landscape, making handicrafts, making different food and beverages, leads the participants to be self dependent and self confident to earn more money. Tourism and recreation facilities bring new way of earning income. In addition, some loans are provided for small scale business for making money with conservation of landscape area. In detail the activities 42, 45 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 2.1.2.2, 2.1.2.3, 2.2.1.1..

### **Activities for Ecological maintenance**

Landscape management helps to maintain the nutrient balance of soil and reduce soil degradation. . The quality of surface water and ground water are managed through sustainable natural resource management. Silvicultural activities like mulching helps to conserve moisture through preventing soil compaction. Land use for reforestation is managed in such a way that attracts tourist and increase aesthetic and recreation value. In detail the activities 45, 46 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 3.1.1.1, 3.3, 3.4.2.1.

### **Activities according to reduce Risk Factors**

Assurance of appropriate soil and water conservation measures reduce the soil erosion through applying landscape management. Encroachment is reduced. Damage by flash flood are decreased to some extent as it is not possible to reduce flash flood quietly without the co-operation upper riparian country. In detail the activities 30, 16 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 4.1.1, 4.1.2, 4.1.3, 4.2.1.

### **Activities for the Livelihood of people**

Landslides are managed, sufficient raw materials of medicinal plants and sufficient seedling are produced for plantation. Women are encouraged to follow these activities around their homestead and they are awarded according to their performances. Infrastructures are charged with high tax within this area. In detail the activities 34, 41, 42, 43, 44 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 5.1.1.1, 5.1.2.1, 5.1.4, 5.2, 5.3, 5.4, 5.5, 5.6

### **Activities for Management planning**

Management follow forest management plan for managing protection forest. Maintenance problems, positive feelings and progress of forest protection are clearly understandable if it is possible to manage a very clear and transparent report. In detail the activities 10, 46 are applied (compare annex) and the following set on C&I and verifiers will be influenced: 6.1.1, 6.1.2, 6.2.1, 6.2.2

#### 4.4 Assessment of six management strategies

Six management (alternative) strategies are assessed based on principles and criteria for Integrated Water Resource Management Framework on the result of the current situation by a qualitative assessment. A qualitative assessment is done according to the intensity of the effect of a management strategy on all criteria. Detailed and specific analysis of each influenced verifier by all alternatives on criteria; are shown (Table 3.11 & Appendix: Design of Annex). The meaning of Symbols are explained below; → = No difference, / = Slight Improvement, ☹ = Moderate Improvement, ☼ = Strong Improvement, ☺ = Very Strong Improvement and ☺☺ = Extreme Influence or Improvement; MS-0 = Current Situation, MS-I = Bio-diversity Conservation Strategy, MS-II = Flood Control Strategy, MS-III Soil and Water quality conservation Strategy, MS-IV = Indigenous Knowledge conservation Strategy, MS-V = Income generating watershed conservation Strategy and MS-VI = Landscape conservation Strategy.

Table 3.9: Qualitative assessment of six management strategies based on principles and criteria and determination of intensity of influencing verifier by six management strategies

Principle	Criteria	MS-0	MS-I	MS-II	MS-III	MS-IV	MS-V	MS-VI
<b>Principle 1. Policy planning</b>	1.1 Proper Legislative Framework	→	☹	→	☼	☹	☹	☹
	1.2 Proper Institutional Framework	→	/	☹	/	☹	☼	☼
	1.3 Watershed management regulations	→	☺	☺	☺	☹	☺	☼
	1.4 Proper Scientific Framework	/	☼	/	/	/	/	/
	1.5 Proper decision making mechanism	→	☺☺	→	/	☹	→	→
<b>Verifier influenced</b>		<b>65</b>	<b>50</b>	<b>19</b>	<b>27</b>	<b>21</b>	<b>25</b>	<b>20</b>

<b>Principle 2. Economic Income</b>	2.1 Contribution margin/net income of farmers	→	☀	☹	☹	/	☀	/
	2.2 Income generation for region/state	→	☀	/	/	☹	☹	/
<b>Verifier influenced</b>		13	13	4	8	5	10	3
<b>Principle: 3. Ecological Maintenance</b>	3.1 Maintenance of Soil fertility	→	☹	→	☹	/	/	/
	3.2 Maintenance of Biodiversity	→	☀	☹	☹	☀	→	→
	3.3 Maintenance of Water quality	→	☀	/	☹	→	☀	☀
	3.4 Identification of degraded sites in the watershed	→	☹	→	→	/	☹	☹
<b>Verifier influenced</b>		31	31	6	11	9	14	15
<b>Principle: 4. Risk factors</b>	4.1 Reduction of soil erosion	→	☹	☹	☹	☀	☹	☀
	4.2 Reduction of illegal extractions	→	☹	→	/	→	/	☹
	4.3 Reduction of flash flood	→	☹	/	→	→	→	→
<b>Verifier influenced</b>		18	13	5	7	8	7	12
<b>Principle: 5. Livelihood of people</b>	5.1 Education and Training	/	/	/	☹	☹	☹	☹
	5.2 Fuelwood production	→	/	→	/	/	☹	☹
	5.3 possibility to produce food	/	☀	/	☹	☺	☺	☺
	5.4 Use of Innovative technology	/	/	/	☀	☹	☀	☀
	5.5 Empowerment of Women	/	☹	☹	/	/	☹	☹

	5.6 Possibilities for Settlement	→	→	/	⊗	→	☀	☀
<b>Verifier influenced</b>		45	15	6	29	26	39	39
<b>Principle: 6. Management planning</b>	6.1 Forest Management Plan	/	/	/	/	/	☀	☀
	6.2 Evaluation and Monitoring	→	→	/	⊗	⊗	⊗	☀
<b>Verifier influenced</b>		19	2	4	8	5	14	19

In table 3.11, the assessment of the management strategies and the number of verifier which are potentially influenced by the management strategies are listed. According to the intensity of influenced verifier, this qualitative assessment could be converted into: No difference as 1, Slight Improvement as 2 and 3, Moderate Improvement as 4 and 5; Strong Improvement as 6 and 7, Very Strong Improvement as 8 and Extreme Improvement as 9;

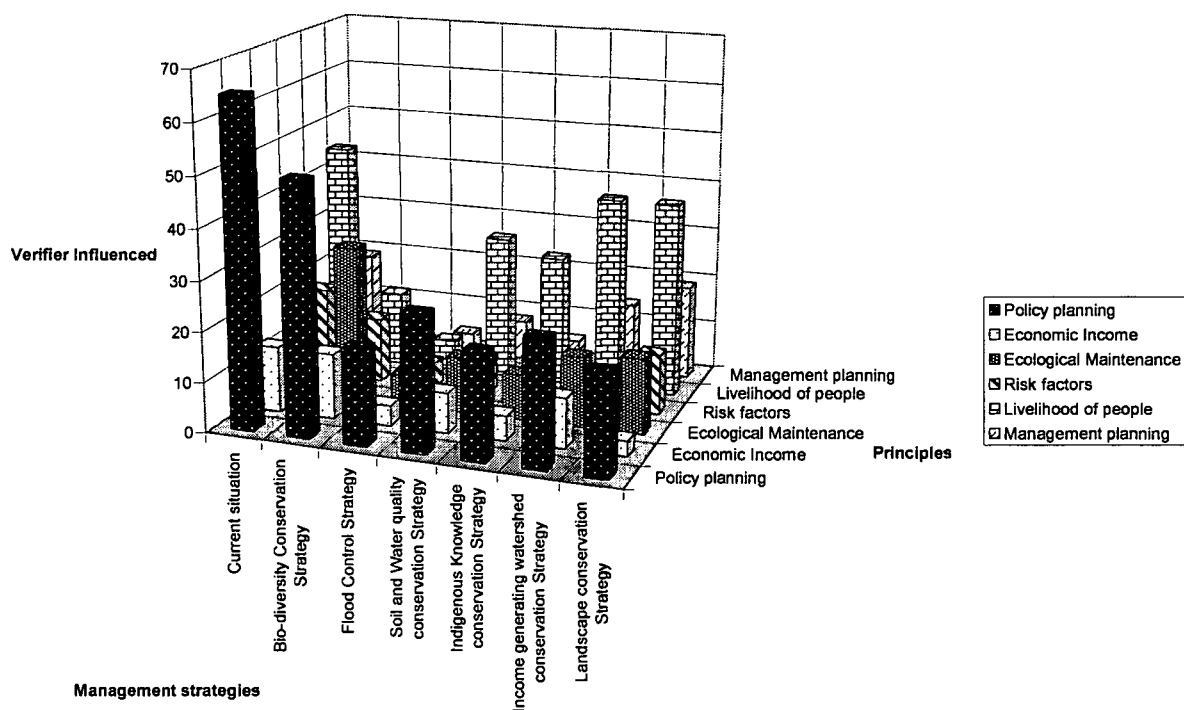


Fig – 4.8: Number of verifier influenced by six management strategies on each principles of IWRM Framework in CHTs through determining each influenced verifier on each criteria of PCIV set.

Total 65 verifiers are influencing on the current situation for policy planning of IWRM where, Bio-diversity Conservation Strategy (MS-I) is performing the best by fulfilling 50 specific

problems or verifier of the current situation, second performance is Soil and Water quality conservation Strategy (MS-III) by influencing 27 verifiers of the current situation.

Total 13 verifiers are influencing on the current situation for principle “Economic Income” of IWRM where Bio-diversity Conservation Strategy (MS-I) can solve 13 identified verifiers that is the highest performance than other management strategies. In the same way, identified 31 verifiers of the current situation are possible to manage by only MS-I. Risk factors of the current situation are influenced by total 18 verifiers where highest 13 verifiers are managed by MS-I than other five management strategies. In case of principle 5 “Livelihood of life”, performance of both Landscape conservation Strategy (MS-VI) and Income generating watershed conservation Strategy (MS-V) are similar for 39 verifiers out of 45 verifiers of the current situation that are higher than other four management strategies. Landscape conservation Strategy (MS-VI) has the highest performance than other five management strategy by fulfilling total 19 verifiers influenced on principle 6 “Management Planning” ( Fig – 3.13).

## 5 Comparing the performance of the management strategies

Bio-diversity conservation strategy (MS-1) is identified as the best and successful management strategy for watershed management according to overall priorities of Integrated water resource management framework in Chittagong hill tracts of Bangladesh. To fulfill the principle 1 “Policy planning”, principal 2 “Economic Income”, principal 3 “Ecological Maintenance”, principle 4 “Risk Factors”, similarly Biodiversity Conservation Strategy (MS-1) is the overall best and stable management strategy. Income generating watershed conservation Strategy (MS-V) and Landscape conservation Strategy (MS-VI) are equally performing and potentially selected management strategy for principle 5 “Livelihood of People” by all key informants. Landscape conservation Strategy (MS-VI) is the anonymous and excellent management strategy for principle 6 “Management Planning” level according to six groups of key informants.

### 5.1 Overall performance of six management strategies for IWRM according to six groups of key informants

By applying the AHP model with the preferences of the six key informants grouped the six management strategies that was able to identify the overall priority for each alternatives. Synthesis from the goal node is presented in the form of a bar graph of the overall priorities of each alternative to obtain global weights for the alternatives. As the aim of the research involves the choice of a best alternative that is influenced by what other alternatives there are and how many of them there are. So synthesized using the distributive mode, Biodiversity Conservation Strategy (MS-1) is the top alternative. Higher priorities for Bio-diversity conservation strategy (MS-1) are excellently similar to all key informants where priorities value of students, watershed specialist and Engineer are higher than other three key informants. The sequences of performance of six management strategies are clear and understandable in Fig- 4.9

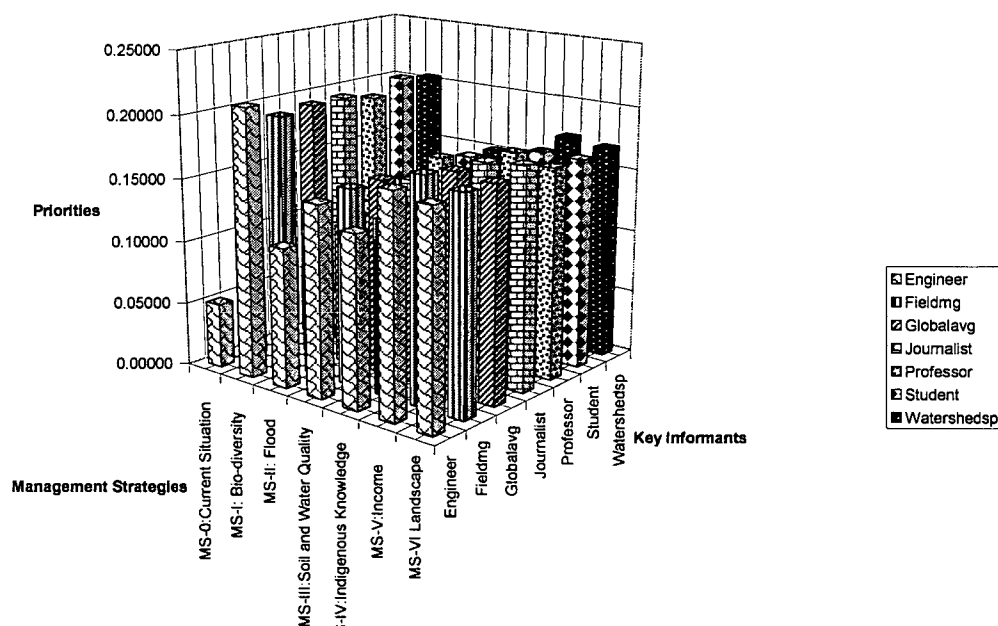


Fig – 4.9: Comparing overall performance of six management strategies for IWRM framework through preferences of six key informants after pairwise comparison

So, Bio-diversity conservation strategy (MS-1) is performing the potential and best compromise management strategy by analyzing the priorities of key informants for six management strategies. The next following management strategies are Income generating watershed conservation Strategy (MS-V), Landscape conservation Strategy (MS-VI), Soil and Water quality conservation Strategy (MS-III), Indigenous Knowledge (MS-IV), Flood Control Strategy (MS-II) and Current Situation (MS-0) respectively (Fig – 4.9).

## 5.2 Performance of six management strategies according to principle 1 “Policy planning”

Biodiversity Conservation Strategy is evaluated by all groups of key informants as the most excellent, consistent and established management strategy for principle 1 “Policy planning” by doing synthesis using distributive mode throughout the AHP model. From the goal node of synthesis in AHP model, the chronological order of other management strategies for Policy planning after Bio-diversity Conservation Strategy (MS-I) according to the priorities of key informants are found: , Income generating watershed (MS-V) conservation Strategy, Landscape conservation Strategy (MS-VI), Soil and Water quality conservation Strategy (MS-III), Indigenous Knowledge (MS-IV), Flood Control Strategy (MS-II) and Current Situation (MS-0) (Fig – 4.10).

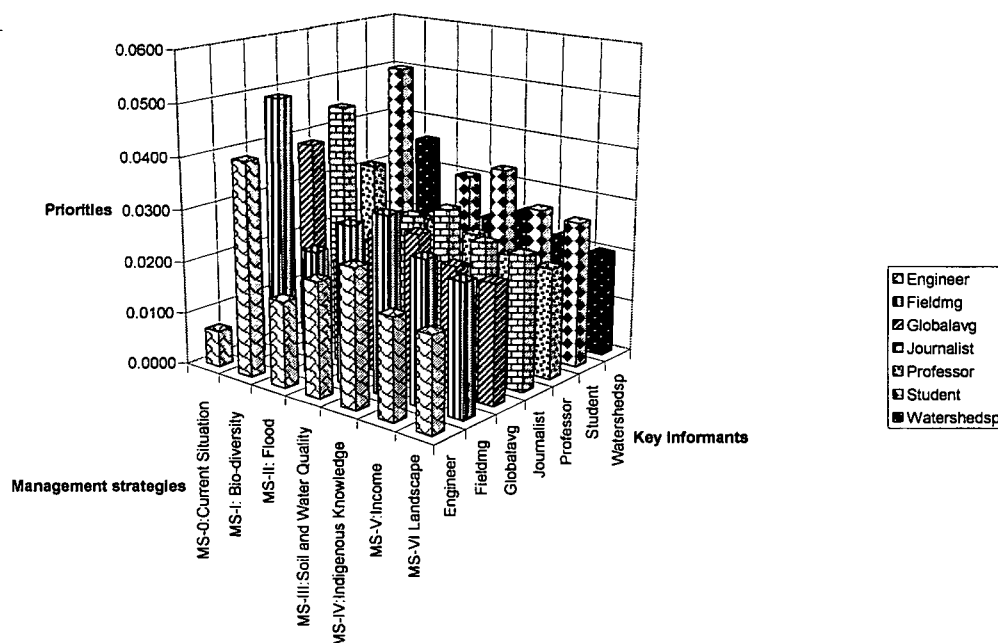


Fig – 4.10: Comparing Performance of six management strategies for principle 1 “Policy planning” according to seven groups of key informants at principal level

## 5.3 Performance of six management strategies according to principle 2 “Economic Income”

Biodiversity Conservation Strategy is the potential choice management strategy for principal 2 “Economic Income” from the goal node of synthesis in AHP model (Fig – 4.11)

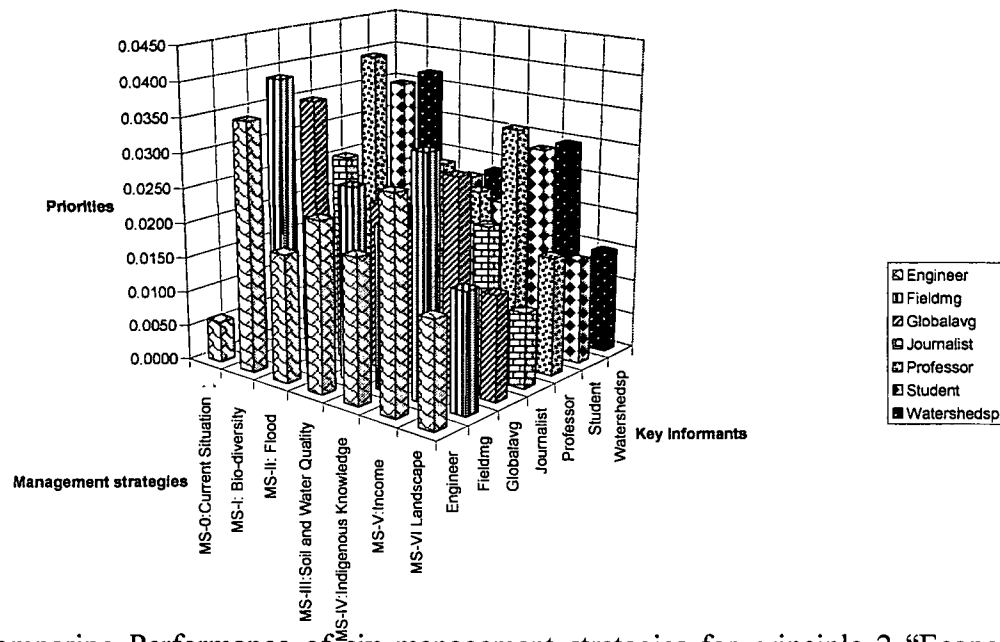


Fig – 4.11: Comparing Performance of six management strategies for principle 2 “Economic Income” according to seven groups of key informants at principal level

#### 5.4 Performance of six management strategies according to principle 3 “Ecological Maintenance”

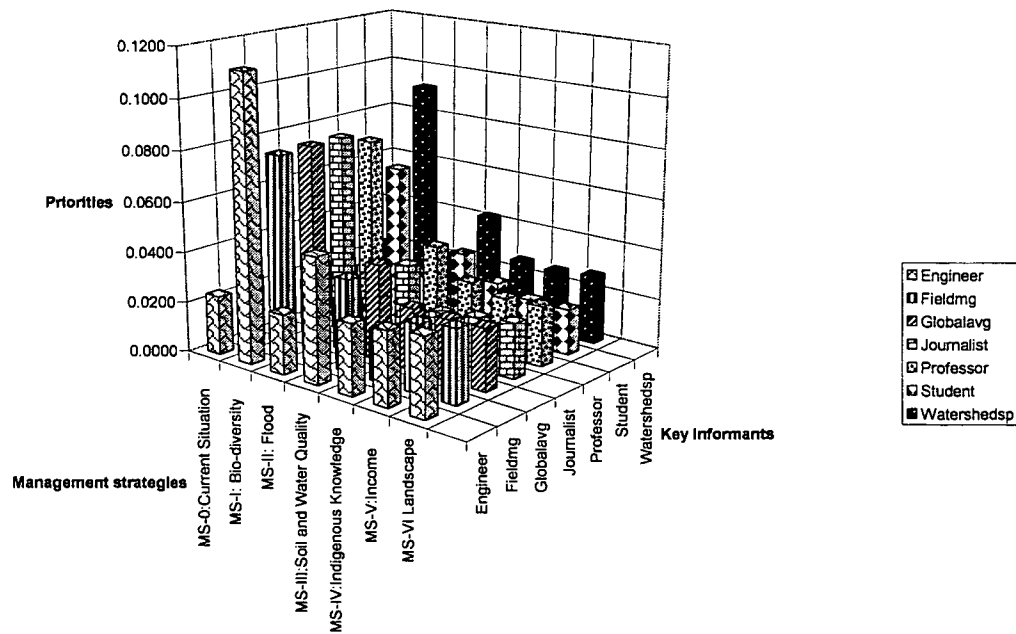


Fig – 4.12: Comparing Performance of six management strategies for principle 3 “Ecological Maintenance” according to seven groups of key informants at principal level

Biodiversity Conservation Strategy is the paramount management strategy at the level of principal 3 “Ecological Maintenance”. The similarity in overall priorities result according to all key informants has proved the most consistency management strategy (Fig – 4.12).

### 5.5 Performance of six management strategies according to principle 4 “Risk Factors”

Biodiversity Conservation Strategy (MS-1) is the top evaluated management strategy at principle 4 “Risk Factors” level where high variation is observed in priorities among Journalist and Field manager (Fig – 4.13)

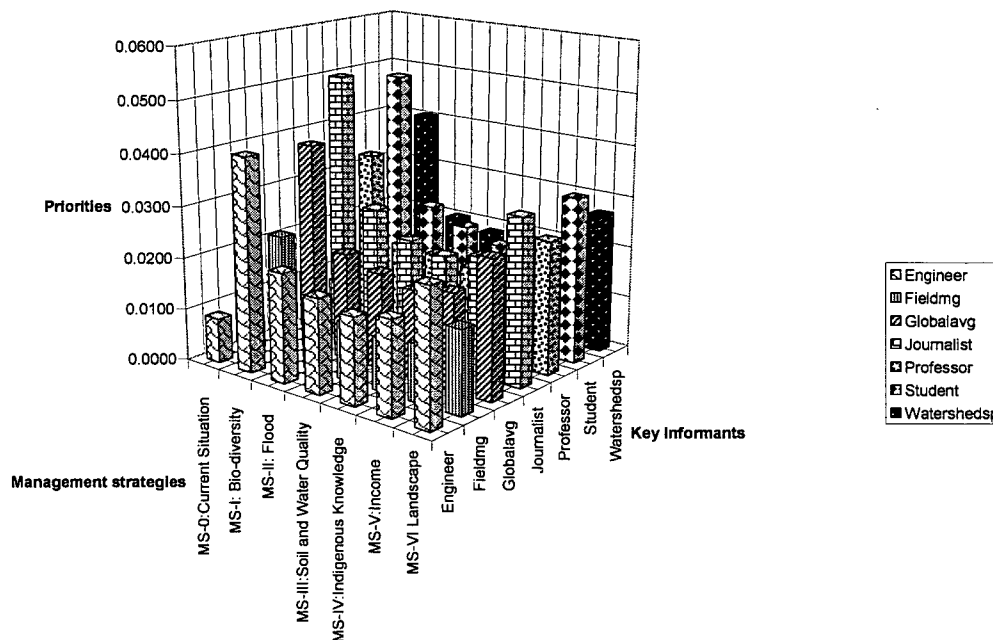


Fig – 4.13: Comparing Performance of six management strategies for principle 4 “Risk Factors” according to seven groups of key informants at principal level

### 5.6 Performance of six management strategies according to principle 5 “Livelihood of People”

Income generating watershed (MS-V) conservation Strategy, Landscape conservation Strategy (MS-VI), are equally evaluated by achieving highest priorities from all key informants for performing stable and best management strategy at for principle 5 “Livelihood of People” by all key informants. Student and watershed specialist group priorities are higher and similar for evaluating best management strategies (Fig – 4.14).

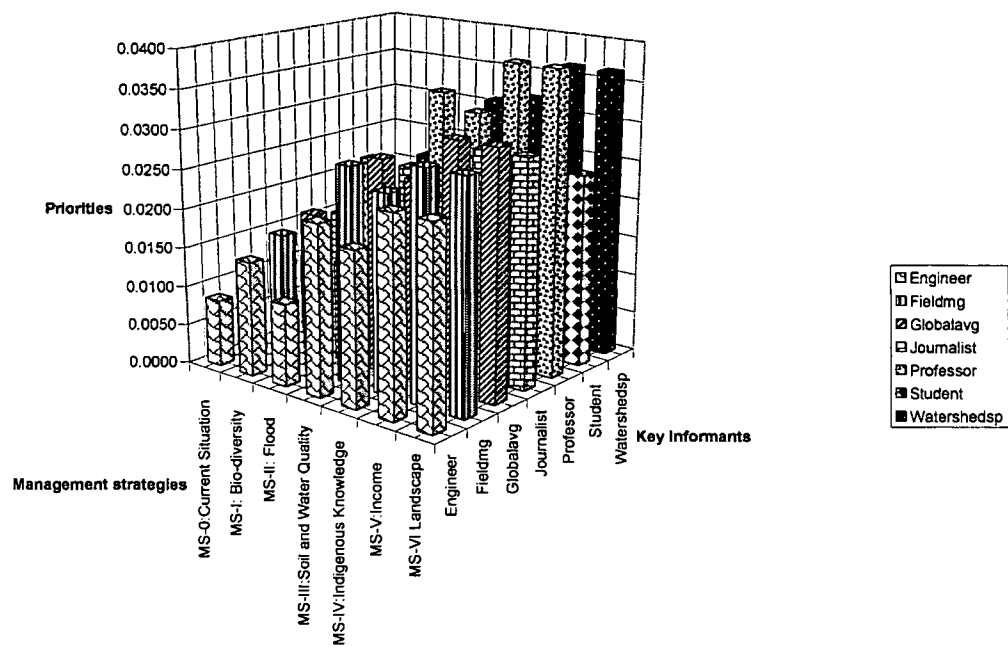


Fig – 4.14: Comparing Performance of six management strategies for 5 “Livelihood of People” according to seven groups of key informants at principal level

## 5.7 Performance of six management strategies according to principle 6 “Management Planning”

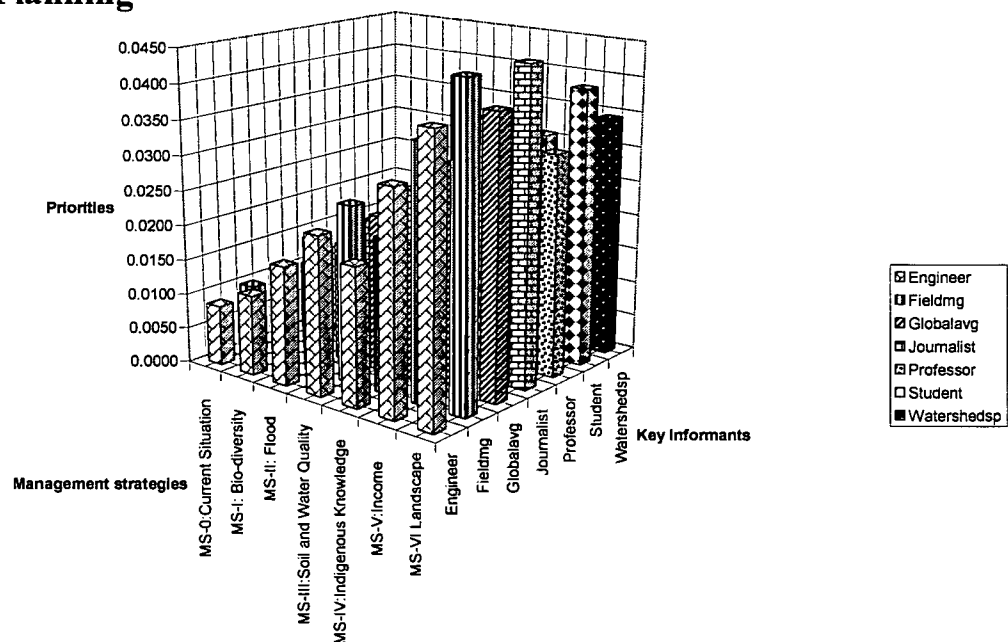


Fig – 4.15: Comparing Performance of six management strategies for principle 6 “Management Planning” according to seven groups of key informants at principal level

Landscape conservation Strategy is the firm and most excellent management strategy at principle 6 “Management Planning” level according to overall priorities of six groups of key informants (Fig – 4.15).

## 6 Discussion

### 6.1 Sensitivity analysis with the AHP

The global average preferences for the IWRM framework at CHTs in Bangladesh of the stakeholder groups is used to investigate the sensitivity of the six management strategies in the AHP model by changing priorities of global average preferences at principle level.

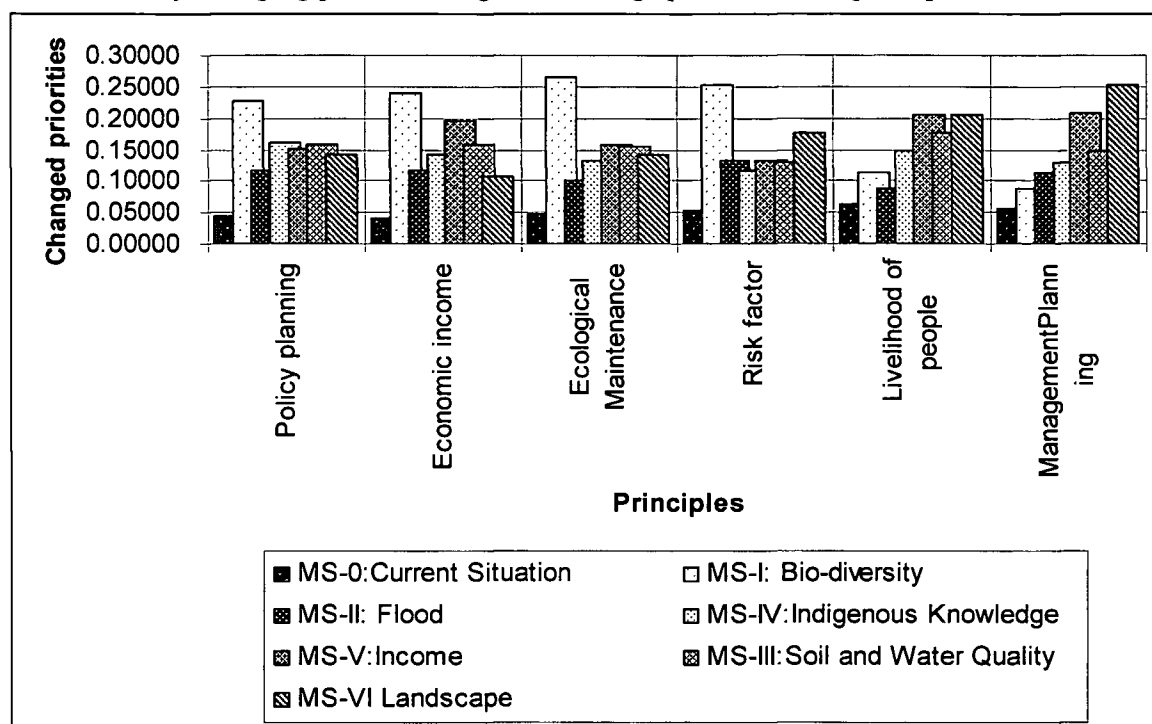


Fig 4.16: Performance of six management strategies at principle level according to sensitivity analysis by AHP

The analysis should help to identify the sensitivity of the management strategies according to different weights of each principle. In sensitivity analysis, each principle of this framework is treated in such a way that each principle was treated as the most important and the others with minor importance respectively. So, six different scenarios could be design, favouring one principle in each scenario. In that context the evaluation system of the IWRM framework with the average stakeholder's preference was found sensitive according to the principle level. Bio-diversity Conservation Strategy is the outstanding option for principles, policy planning, economic income, ecological maintenance and risk factors. Income generating watershed conservation strategy and Landscape conservation strategy are similarly performing at best for principle livelihood of people. Landscape conservation strategy is performing at the best for management planning. So sensitivity analysis indicates that none of the strategies is overperforming against the other according to changes of preferences. For that reason, there is a need to negotiate between different stakeholders groups and find a compromise solution for implementing IWRM.

## 6.2 Justification of IWRM strategies in CHT

The effective and skilled use of MCA (Multi-criterion analysis) for evaluating Integrated water resource management; helps to address the existing situation explicitly and measure the complexity of problems in a transparent and understandable way through establishing principles, criteria, indicator and verifiers. However, the selection of stakeholders is one of key tasks of C & I planning, developing and designing. Watershed specialists, Professors, Students, Field managers and journalists have been selected according to the professional relevance in CHTs. Key informants preference elicitation was very tough task with relevant stakeholders of CHTs IWRM framework as they were not familiar with the meaning of principles, criteria, indicators and verifier as well as ranking and rating method. Key participants were so knowledgeable, experienced and interested to give their preferences about the existing problems of CHTS so that strength of final C & I set, was surprisingly and robustly acceptable to all groups. As, stakeholders had to express their preferences for each indicators under each criteria and for each criteria under each principles by both ranking and rating method, so, preference elicitation has been found to stakeholders as very technical and time consuming. However, the Analytic Hierarchy Process could not be used in the field either as it is totally impossible to apply it with different stakeholders due to its mathematics and the calculation of overall priority weights.

An additional strength of applying C & I approach for IWRM in CHTs, is used to develop a information base within a system, (e. g, Sustainable Forest Management) that assist to decrease the information gap between the local level with national, international and global level. In addition, there are immense scopes to know the problems and feedback from different key informants during preference elicitation. The analytical hierarchy process (AHP), formulated a comprehensive, logical and structured framework for Integrated Water Resources Management in Chittagong hill tracts of Bangladesh. It allows to improve understanding of complex decision problems by decomposing the problem in smaller parts in a hierarchical structure. This hierarchy gives a transparent and clear picture consisting of principles, criteria, indicators and verifiers and allows to evaluate decision alternatives. The incorporation of all relevant decision criteria, their pair-wise comparison and a measure for the consistency of the judgments allows the decision maker to improve the coherence among redundant judgments.

Six management alternatives are developed for IWRM on the basis of short term and long term basis according to the current problems of watershed in CHTs. Biodiversity conservation is a long term water resource conservation strategies with bio-diversity conservation. Flood management is the instant strategy to handle the flood situation through water resource management. People participation for water resource and environmental conservation are tried to be encouraged through generating income by Income generating watershed management. Soil and water quality conservation strategies are recommended to control the serious degradation of soil erosion and maintain the scarcity of water quality and quality. Indigenous knowledge management alternatives may help to conserve water resources by utilizing valuable ethnic and cultural resources. Landscape conservation strategies are discussed to increase the economic value of landscapes with watershed conservation through involving people.

According to ADB (2001), CHT hill ecosystem is now said to be very much degraded which has a direct and close relationship with chronology of impoverishment, negative policy implications

and political instability in the region. Shifting cultivation is the primary occupation and major economic activities of the tribal people living in Chittagong Hill Tracts. This cultivation system is widely practiced by the tribal people in Chittagong Hill Tracts constituting about 32500 ha annually (Shoaib *et al.* 1998). Although shifting cultivation was environmentally suitable in the past, when population pressure on land was minimum, but it presently caused adverse impacts on the environment with the gradual increase of the local population and migration of low land people. All climax vegetation has been destroyed by shifting cultivators with incendiary fires (Rasul, *et al.* 2004). So, improper agricultural practices, illegal logging and bamboo extraction are also serious problems for deteriorating natural resource base. Another main environmental concern in the region, is the rapid depletion of natural forest resources. Land and watershed have been degrading due to improper land use practices mainly by the migrated population and the short rotational jhum practice by indigenous groups, consequently causing soil erosion, siltation of lakes and rivers and soil fertility decline thereby creating food insecurity situation in the region. Agro-forestry system can combine short-term and long-term benefits for the sustainable watershed protection and to reduce poverty and protect watersheds in the CHTs (Nath, *et al.*, 2005).

Land degradation in CHT by water erosion is adding to the costs of producing food and increased prices of harvested crops thereby adding to the cost of living and livelihood. Land degradation symptoms in CHT include: Massive loss of top soil due to devastating soil exhausting farming practices, decrease in soil fertility and productivity due to declining soil nutrient reserves, increased trend in the use of fertilizers and pesticides, declining quantity and quality of soil resource bases, drying up of natural water sources including streams, waterfalls and seepage water, pollution of water and siltation of lakes and river systems, rising incidences of flash floods and landslides, Loss of biodiversity (BANCAT, 2006)

If it might be possible to implement the idea of “Bio-diversity management” alternatives at Bandarban in Chittagong hill tracts, it would solve the problems of the current situation mentioned under different criteria, indicators and verifiers with possible activities (4.3.1 and Appendix). The capacity of this alternative within IWRM Framework are clearly mentioned and explained according to six principles, policy planning, economic income, ecological maintenance, reduction of risk factors, livelihood of people and management planning (4.3.2). The preferences analysis for “Bio-diversity management” by key informants and in relation to the performances of the other management strategies according to each principle improved the acceptability, strength and potentiality of identifying the best alternatives for Integrated water resource management in Chittagong hill tracts of Bangladesh:

- If, discussion and participation of stakeholders are organized and maintained in a IWRM framework, there is hope, that ownership right would be ensured through training on land issues and related laws, forming advocacy team, lobbying and networking team by managing first principle, policy planning.
- Language barrier might be solved involving local institution through creating linkage and awareness about IWRM among local people.
- For effective land management, watershed certificate would motivate and increase people participation in IWRM management activities.
- Economic self efficiency may be achieved through implementing the activities like eco-village establishment, threatened watershed management, re-excavation pond for drinking

and fish culture, plantation raising along the edge of the ponds, off farm activities like vegetable gardening, bee keeping, cotton cultivation, crab culture, nursery establishment.

- It might be possible to manage third principle, ecological maintenance so that rich bio-diversified sites would be expected to be conserved. People would be aware of cleaning and managing blocked and threatened water reservoir and also conserving local medicine, herbs, shrubs, raising plantation on vacant place and maintaining soil fertility, sustainable biodiversity management, and water quality maintenance by rain water harvesting. Available vacant space around the home gardens of CHTs would be planted with multipurpose tree species to meet the demand for timber, fuel wood, fruit, fodder, and raw materials etc.
- Flash flood and soil erosion would be naturally reduced through conservation of water catchment area considering fourth principle, risk factors.
- Fifth principle might fulfill the demand for livelihood of people by arranging training and demonstrate activities, establishing environmental school, distributing sapling, weaving design, cane and bamboo works.
- Collaborative plan through sixth principle, management planning that might cover all components like Resource planning, people participation, extension services. Thus, annual documentation and reporting would help to realize the existing situation, response, acceptance and consequences of the management strategy.
- As forest production take lots of time, in that case poor people may be attracted to agricultural produce like tomato, potato, maize, rice that give short production return. So, we need to highlight the agricultural production to fulfill their demand of food and then, hilly people may join educational programme and environmental protection activities. Local people might utilize their land for rearing poultry, bamboo, cane, medicinal plants. Nursery of traditional medicinal plants would fulfill the demand of health services of the local people, but also to meet the demand of some herbal industries. Use of pesticides in agriculture would be stopped so that it cannot be spread in water reservoir system. Pest and diseases survey and its remedial measures, should be taken into consideration.
- Available innovative or local or low cost or improvised technologies would be managed in cost-effective way to ensure the quality of water as water purification plants that are so costly. For hilly people, it is very tough to get underground water by shallow tube-well as they are so poor to arrange shallow tube-well as well as collection of surface water.
- Furthermore, identified management system is considered for implementation in a practical way and responsibilities are awarded according to the performance of managing problems like illegal logging, deforestation. If forest managers are actively conscious, 80% illegal extraction of timber is expected to be stopped. Co-operative marketing facilities would ensure valuation of their products as well

Now it is very important to start the implementation of different phases of watershed management through IWRM framework. It is unexpected from many projects of developing countries, generally, stakeholders and participants supported the initiation of watershed management studies by conservation authorities rather than continuing long term conservation processes.

### 6.3 Future direction of IWRM in CHTs

DSS (Decision Support System) could be an advanced approach to handle the unstructured problems of Chittagong hill tracts in Bangladesh. Integrated Decision Support System provides decision maker with the ability to look into the future and to make the best possible decision based on past and present information on future predictions to ensure an efficient allocation, protection and management of water resources by ensuring trade-off between different mutually exclusive values and interests which exacerbate conflicts (Walkers, *et al.* 2001). As a consequence of these new environmental problems, the process of policy making has increasingly favored interdisciplinary, pluralistic, and inclusive methodologies, with scientists participating alongside other stakeholders in deliberative decision making, participatory assessment or group model building.

Many international agreements and initiatives such as Agenda 21 and 6<sup>th</sup> EU Environment Action, Millennium Development Goal (MDG) and NWMP (National Water Management plan) are focusing to improve tools for attaining sustainable development as well as for bridging the science and policy spheres due to expansion of information and knowledge of the links among watershed components and feedback processes at spatial and temporal scale. According to Khan (2004), for example, an application of River basin Model, MIKE BASIN model on Ganges-Brahmaputra- Meghna river system has been presented for assessment of temporal and spatial variations of water abundance and shortages in Bangladesh. The model has produced facts on the effects of existing major irrigation projects on water availability. The utilization at national level and the identification of potential water resource development schemes and their post project impacts such as Dhaka Surface Water Supply project from Lakhya river, flow diversion at Ganges Barrage Project, full future development of irrigation schemes as well as the adverse impacts from social point of view during drinking water shortages events helped to improve the overall situation.

## **7 Conclusions**

This research works on “Evaluation of management strategies in CHTs watershed” is one the first initiatives to identify a compromise solution for integrated water resources management that fulfill key issues of IWRM in Bangladesh. It also found demands and problems of a mountain watershed community through mutual learning within CHTs IWRM Framework and also build an information base with the help of key informants. The key informants have been free to discuss all activities, problems and experiences and they could produce alternatives for solving the problems. Although, these activities seem to be a dream of future because, it is very hard to integrate all ideas of all stakeholders in a discussion round as well as find an acceptable solution at a time as most of the people are illiterate and far away from understanding about their right as a citizen of nation. In addition the information base of the research not only assists to decrease information gap between the local level of CHTs with the national, international and global level, but also help decision makers to identify perceptions of IWRM of key informants.

Biodiversity conservation strategy is identified as a best compromise management strategy for sustainable management of a mountain watershed in the Chittagong Hill Tracts (CHTs) through the help of local expert's preferences using a MCA method, pairwise comparison and sensitivity analysis of the results by changing preferences. Government should start to take initiatives to integrate multilevel institutions to apply and utilize this research results in practical actions in Chittagong hill tracts. The Biodiversity conservation strategy has the strength to tackle with the problems of negative policy planning, with decision making mechanism within IWRM framework and involves diverse stakeholders like field manager, member from religious organization, forest managers, researchers, upazila administrator and local committee. Collaborative plan of Bio-diversity management strategies fulfill the demands of creating awareness about confirming ownership right, come across language barrier, clarification of problems through intensive and well defined research with the help of multi-level institutions. Effective land management will be encouraged through ensuring watershed certification with the help of political awareness. Watershed management through establishment of Eco-village will increase the economic efficiency of people by doing different off farm activities with natural resource conservation. Rich bio-diversed sites will be discovered, restored and recovered. The target of the MDG, 20% forest land within 2015 will be fulfilled. Maximum utilization of resources will be ensured through different land use classification system like Bio-diversity zone, Flood management zone, Soil and water quality conservation zone, Indigenous knowledge conservation zone, self income generating conservation zone and landscape management zone. As a consequence, environmental risks like flash flood, soil erosion will be reduced and illegal encroachment will be controlled. Local people will know the different means of earning money through natural resource conservation and management. All activities, problems and experiences will be documented and reported to handle and manage the situation effectively.

## 8 References

Abbas, B. M. 1982. The Ganges water dispute (University Press Limited, Dhaka).

Achmad, H., Martadihardja, A. and Suharto, 1980. Cultural and social aspects of homegardens. In J. I. Furtado, ed., Tropical ecology and development. Proceedings of the Fifth International Symposium of Tropical Ecology, The International Society of Tropical Ecology, Kuala Lumpur, Malaysia pp. 453-457.

ADB, 2001. Chittagong Hill Tracts Region Development Plan (ADB TA # 3328- BAN), *Final Report. 4: Natural Resources and Forestry*©.KIT in association with SODEV Consult CDP, ATCADIS EURO CONSULT DPC.

ADB, 2000. Report and Recommendation of the president to the Board of Directors on a proposed loan to the People's Republic of Bangladesh for the Chittagong Hill Tracts Rural Development Project.p.72.

ADB, 2004. Water Champion: Hamidur Khan on flood management, Coping with the worst of floods,[www.asiadevbank.org/Water/Champions/khan.asp](http://www.asiadevbank.org/Water/Champions/khan.asp)

ADB (Asian Development Bank). 2005. <http://www.adb.org/environment/aeo/>

APO(Asian Productivity Organization), 2004.Evolving Sustainable production Systems in Sloping Upland Areas-Land classification issues and options. In, T. Pratap(ed), Report of the APO study meeting on Land Classification in Sloping Upland Areas for Sustainable Production System held in 10-17 July 2002.pp.80-93.

Arya, L.M., 2000. Final consultancy reports on hill agriculture. Agricultural Research Management Projects (ARMP), Bangladesh Agricultural Research Institute, Gazipur, Dhaka.

Ahmed, Q. K. 2000. Bangladesh Water Vision 2025: Towards a Sustainable Water World.“ Dhaka: Bangladesh Water Partnership.

Ahmed, S. 2002. Tree Plantation Action and Tree fair 2002 in Bandarban, Ministry of forestry and Environmental sciences.P52.

Alam , M. F and Mong, N. 2004. Environment: Committed to people's right to know. The Daily Star. Vol. 5. No. 22. 18june, 2004.

Ananda, J., Herath, G., 2003. The use of Analytic Hierarchy Process to incorporate stakeholder preferences into regional forest planning. Forest Pol. Econ. 5, 13–26.

Annual Report 2001, ITDG- Bangladesh.

Annual Report 2005-2006, WARPO- Bangladesh.

Asiatic Society of Bangladesh, Dhaka, Bangladesh.

Bailey, D.E., Loos, J.J., Perry, E.S., Wood, R.J., 2000. A retrospective evaluation of 316(b) mitigation options using a decision analysis framework. *Environ. Sci. Pol.* 3, 25–36.

Bakkes, J.-A.; Van Den Born; G.-J.; Helder, J.-C.; Swart, R.-J.; Hope, C.-W.; Parker, J.-D. 1994. *An Overview of Environmental Indicators: State of the Art and Perspectives*. UNEP/EATR.94-01; RIVM/402001001. Nairobi Environmental Assessment Sub-Programme, United Nations Environment Programme.

Banglapedia, 2007. [www.banglapedia.com](http://www.banglapedia.com).

BANCAT, 2006. [www.bangcat.org](http://www.bangcat.org).

BARC(Bangladesh Agriculture Research Council), 1999. Land Degradation Situation in Bangladesh, Soils division, Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

BARCIK, 2004. Peoples living in the plains are habituated to flash floods, Bangladesh Resource Centre for Indigenous Knowledge. Belhaven Press, London, U.K.

Barua, B.P., 2001. Ethnicity and National Integration in Bangladesh: A study of the Chittagong Hill Tracts. Har-anand Publications Ltd., New Delhi, India.

Beasley, B. 2001. Background Report: Criteria & Indicators Briefing Paper. P.30.

Beattie, B. B. 1969. Watershed conditions and watershed research needs in Chittagong Hill Tracts. Project Report 2, UNDP/FAO Project, BGD/72/005, BFRI, Chittagong, Bangladesh.pp1-15.

Brang, B. Courbaud, A. Fischer, I. Kissling-Näf, D. Pettenella, W. Schönenberger, J. Spörk and V. Grimm, Developing indicators for the sustainable management of mountain forests using a modelling approach, *For. Pol. Econ.* 4 (2002), pp. 113–123.

Bryant, R.L., 1997. The Political Ecology of Forestry in Burma. C. Hurst & Co. Ltd., London.

Bromley, J, 2005. Guidelines for the use of Bayesian networks as a participatory tool for Water Resource Management based on the results of the MERIT project. CEH, Wallingford, UK.

Calendar, I. R. 1998. Review outline of water resource and land use issues (IIMI) SWIM Paper, No.3.

Calendar, I. R. 1999, The Blue Revolution, Land Use and Integrated Water Resources Management, Earthscan.

Carabelli F. A.\*, M. M. Jaramillo, D. Szulkin-Dolhatz & M. Gómez (Patagonian Andes Forest Research and Extension Center (CIEFAP), Patagonia, Argentina) Management tools for using and preserving natural resources: Criteria and Indicators For Multiple Use of Forests in Andean Patagonia of Argentina p.32.

Castelletti, Andrea and Rodolfo Soncini-Sessa: Topics on system analysis and integrated water resources management. Elsevier book. Chapter 3.

CHARM , 2006. Chittagong Hill Tracts Improved Natural Resource Management Report on the National Workshop held in Rangamati, Bangladesh 15 - 16 February 2006. CHARM Project Report 1. Chittagong, Bangladesh.

Chowdhury, M. S. 2003. CHOLEN: Approach to Promote Education in Ethnic Communities in Bangladesh: New Horizons for Learning, <http://www.newhorizons.org> , [info@newhorizons.org](mailto:info@newhorizons.org)

CIFOR. 1997. CIFOR Annual Report 1996. CIFOR, Bogor, Indonesia. CIFOR Annual Report. 66p.

CIFOR. 1999. *CIFOR criteria and indicators generic template*. The Criteria and Indicators Toolbox Series No. 2. CIFOR C&I Team.

Creighton, S. C. 1999. Learning to plan for IWRM in British Columbia. The University of Development and Environment, Berne, Switzerland.

DANIDA (Danish International Development Agency), 2000. Identification report. Watershed development project, Chittagong Hill Tracts, Bangladesh.

Dietrich, J, Schumann, A. H and Lotov, A. V. 2004. IFAC Workshop on Modelling and Control for Participatory Planning and Managing Water Systems, Venice, Sept. 29th - Oct. 1st 2004p10.

DFID, 2002. A Review of DFID's Country Strategy for Bangladesh: CSP 1998-2002.p54.

EC, 2006. National Indicative Programme of European Community Support 2006, Bangladesh.

Eliasuddin, M. 2005. Degradation of Upland Watershed in Chittagong and Chittagong Hill Tracts, a project paper for B.Sc(Hons) in Forestry. Institute of forestry and environmental sciences, University of Chittagong, Chittagong, Bangladesh p.90.

FAO, 2000. Land-Water Linkage in Rural Watersheds Electronic Workshop 18<sup>th</sup> September-27<sup>th</sup> October 2000: Land Use Impacts on Water Resources p26

FAO, 2004. Background document to the FAO/Netherlands Conference on Water for Food and Ecosystems, Ministry of Agriculture, Nature and Food Quality, The Netherlands

Farid, A.T., Iqbal, A. and Karim, Z., 1992. Soil Erosion in the Chittagong Hill Tracts and Its Impact on Nutrient Status of Soils, Bangladesh Journal of Soil Science, Vol. 23 (1&2), Page 92-101.

FD, 2007. [www.bforest.gov.bd](http://www.bforest.gov.bd).

Fisher, B.E.A., 2006. Fuzzy approaches to environmental decisions: application to air quality. Environ. Sci. Pol. 9 (1), 22-31.

Fernandes, L., Ridgley, M.A., van't Hof, T., 1999. Multiple criteria analysis integrates economic ecological and social objectives for coral reef managers. *Coral Reefs* 18, 393–402.

Forestal (Forestal Forestry and Engineering International Ltd.), 1966. Reconnaissance soil and land-use survey, Chittagong Hill Tracts, Vancouver, Canada.

French, S., Geldermann, J., 2005. The varied contexts of environmental decision problems and their implications for decision support. *Environ. Sci. Pol.* 8 (4), 378–391.

FSC. 1994. Forestry stewardship principles and criteria for natural forest management. Forestry Stewardship Council, Oaxaca, Mexico.

FSP, 2003. Participatory Management Plans: Bandarban and Lama Forest Divisions (Ten years plans), Forest Department, Ministry of Environment and Forests, Dhaka, ADB Project BAN NO. 1486, Tecslut International Limited. P.138.

Gafur, A., Jensen, JR., Borggaard, O. K and Petersen, L. 2003. Runoff and losses of soil and nutrients from small watersheds under shifting cultivation (Jhum) in the Chittagong Hill Tracts of Bangladesh. *Journal of Hydrology*. 279: 293-309

Gafur, A., 2001. Effects of shifting cultivation on soil properties, erosion, nutrient depletion and hydrological responses in small Watershed of the Chittagong Hill Tracts of Bangladesh. Doctoral dissertation, The Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Gani, M. 1998. Medicinal Plants of Bangladesh: Chemical Constituents and Uses of 460 Species.

Giupponi, C., 2006. Decision Support Systems for implementing the European Water Framework Directive: The MULINO approach. *Environmental Modelling & Software*, In Press, Corrected Proof. L.T.H. Newham, R.A. Letcher, A.J. Jakeman, T. Kobayashi, 2004. A framework for integrated hydrologic, sediment and nutrient export modelling for catchment-scale management, *Environmental Modelling & Software*, 19: 1029–1038;

Giupponi, C., Mysiak, J., Fassio, A. and Cogan, V., 2004. MULINO-DSS: a computer tool for sustainable use of water resources at the catchment scale. *Mathematics and Computers in Simulation*, 64(1): 13-24;

GoB(Government of Bangladesh) and UN(United Nations), 2005. Millennium Development Goals: Bangladesh Progress Report.p.88.[www.LCGbangladesh.org](http://www.LCGbangladesh.org).

GLI - Water in Chittagong Hill Tracts - Bangladesh, Future abstract of Water in Chittagong Hill Tracts (CHT) - Bangladesh. ... boring safe water technology, seasonal disorder, water quality in terms of iron, [www.glinet.org/inspiredetail.asp](http://www.glinet.org/inspiredetail.asp)

Global Water Partnership(GWP), 2000. Integrated Water Resources Management. Technical Advisory Committee (TAC) Background Paper no.4. Stockholm, Sweden

Global Water Partnership, 2004. Unlocking the door to social development and economic growth: how a more integrated approach can help. Tech policy brief 3.p8.

Global Water Partnership, 2006 a. Checklist for change: Defining areas for actions in an IWRM strategy or plan. Tech brief 1.p8.

Global Water Partnership, 2006 b. Monitoring and evaluation indicators for IWRM strategies or plans. Tech brief 3.p8.

Golden, B., Harker, P. and Wasil, E. 1989. The Analytic hierarchy process: Applications and studies. Springer Verlag, the Netherlands.

Goni, O. 1998. Tree Plantation Action and Tree fair 1998: C Forest Resources, The Ministry of Forestry and Environmental sciences.p33

Gupta, R. S., 2001. *Hydrology and Hydraulic Systems*. Waveland Press, Illinois, USA.

Hammond, A.; Adriaanse, A.; Rodenburg, E.; Bryant, D.; Woodward, R. 1995. *Environmental Indicators: a Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development*. Washington DC. World Resource Institute.

Handfield, R., Walton, S. V., Sroufe, R., Melnyk, S. A. 2002. Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process, *European Journal of Operational Research*, 141, 70–87.

Hans Jørgen Henriksen ed., 2004. Test of Bayesian belief network and stakeholder involvement, Ministry of Environment Geological Survey of Denmark and Greenland (GEUS) pub. (www.geus.dk)

Haque, M. 2000. Indigenous knowledge and practices of the people of the Chittagong Hill Tracts in Bangladesh. In: Of Popular Wisdom: Indigenous Knowledge and practices in Bangladesh. Khan, N. A. (ed), BARCIK, Dhaka, Bangladesh.pp129-134.

Hassan, M. 1999. *Soils of Bangladesh: their genesis, classification and use potentials*. The March Printers, Narinda, Dhaka.

Heathcote, Isobel W. 1998. Integrated Watershed Management: Principles and Practices. John Wiley & Sons, Inc. New York.

Henriksen, Hans Jørgen, Rasmussen, Per, Brandt, Gyrite, Bülow, Dorte von and Jensen, Finn Verner, 2007. Bayesian networks as a participatory modelling tool for groundwater protection.

Henriksen, Hans Jørgen, Rasmussen, Per, Brandt, Gyrite, Bülow, Dorte von and Jensen, Finn Verner (in prep.) Public participation modelling using Bayesian networks in management of groundwater contamination. Environmental Modelling & Software, In Press, Corrected Proof, Available online 3 April 2006.

Herweg, K., Steiner, K., Slaats, J. (eds.). 1998. Sustainable Land Management

Hewlett, 1982. Principles of Forest Hydrology, The University of Georgia press, Athens.

Hettelingh, J.P.; De Hann, B.J.; Strengers, B.J.; Klein Goldewijk, C.G.M.; Van Woerden, J.W.; Pearce, D.W.; Howarth, A.; Ozdemiroglu, E.; Hett, T.; Capros, P.; Georgakopolous, T.; Cofala, J.; Amann, A. 1998. *Integrated Environmental Assessment of the baseline scenario for the EU State of the Environment*. 1998 Report. The Netherlands,

Hossain, A, 2004. People's Initiative for Transboundary River Basin Management: People's Initiative for Transboundary River Basin Management, The Institution of Engineers, Bangladesh, and Managing Director, Dhaka WASA. pp 110-350

Hurst, A. 2003. State forestry and spatial scale in the development discourse of post-colonial Tanzania: 1961-1971

ITDG, 2001.[www.ictsd.org](http://www.ictsd.org)

ICIMOD, 2003. Annual Report 2003: Collaborating with member countries. [www.icimod.org](http://www.icimod.org). p.17

ICIMOD, 1999. Land Policies, Land Management and Land Degradation in the Hindu Kush-Himalayas: Bhutan Study Report, Policy and Planning Division, Ministry of Agriculture, Royal Government of Bhutan p39.

IDMC(Internal Displacement Monitoring Centre), 2006. Bangladesh: Minorities increasingly at risk of displacement. [www.internal-displacement.org](http://www.internal-displacement.org).p.31.

IISD (International Institute for Sustainable Development). 1999. 'Beyond Delusion: A Science and Policy Dialogue on Designing Effective Indicators for Sustainable Development'. Workshop Report.

ITTO. 1992. Criteria for the measurement of sustainable tropical forest management. International Timber Trade Organization, Yokohama, Japan.

Integrated Water Management: International Experiences and Perspectives. Belhaven Press, London, U.K.

IUCN, 2004. National Bio-diversity Strategy and Action Plan, Ministry of Environment and Forest, GoB, Dhaka, Bangladesh. p.72. [www.sdnpsbd.org](http://www.sdnpsbd.org).

IUCN , 1991. *National Conservation Strategy of Bangladesh (Draft)*, International Union for Conservation of Nature and Natural Resources, Ministry of Environment and Forest, GoB, Dhaka, Bangladesh. P. 83.

JWF(Japan World Water Forum), 2007. [www.waterforum.jp](http://www.waterforum.jp)

Ahmed, K., , Kamaluddin, M. and Ullah, M.,1999. Land policies, Land management and Land degradation in the Hindu Kush-Himalayas-Bangladesh Study Report, MFS Case Study Series No.99/1, ICIMOD, Kathmandu, Nepal.63 pp.

Khan, M. A. B, 2004. Geophysical Research Abstracts, Vol. 6, S Ref-ID: 1607-7962/gra/EGU04-A-00004, European Geosciences Union 2004.

Khan, M. A. A and Haque, S. M. S. 2003. Features and Characteristics of Bangladesh Watershed. B.Sc(Hons) Project paper, Institute of forestry and environmental sciences, University of Chittagong, Chittagong, Bangladesh. p51.

Khan, B. U., 2003; CHTs governance Study: An Institutional review. CARE Bangladesh, Dhaka,

Khan, J. A. 2004. Combination of Variety in Rangamati(in Bengali).p.342.

Khan, N. A. 2002. Farming Practices and Sustainable Development in the Chittagong Hill Tracts 272 p

Khan, F.K., Khisha, A.L., 1970. Shifting cultivation in East Pakistan. *The Orient. Geogra.* 14: 24-43.

Khisa, S. K., Shoaib, J. U. and Khan, N. A., 2006. Conservation Approaches and Technologies of Hill Farming and Natural Resource Management Practices Documented from Chittagong Hill Tracts, Bangladesh, BANCAT, CHTDB. Khagrachari

Knudsen, J.L., and Khan, N.A., 2002. An exploration of the problems and prospects of integrated watershed development in the CHT. *In: Farming Practices and Sustainable Development in the Chittagong Hill Tracts*, Khan, N.A., Alam, M.K., Khisa, S.K. and Millat-e- Mustafa M. (Eds.), CHTDB and VFFP –IC, Chittagong, Bangladesh, pp. 165-180.

Krishi kotha, 2005. In P. Sarkar. Atikur, an successful man, Agro-forestry series 5.p.186. National Water Policy, 1999.[www.bangladeshgateway.org](http://www.bangladeshgateway.org)

Lammerts van Bueren, E. and Blom, E. 1997. Hierarchical framework for formulation of sustainable forest management standards. The Tropenbos Foundation, Wageningen, The Netherlands.

L.T.H. Newham, A.J. Jakeman and R.A. Letcher (submitted) End-User Participation in Modelling for Integrated Catchment Assessment and Management: An Australian Case Study in Participation, *International Journal of River Basin Management*.

LCG, 2003. LCG Comments on Bangladesh I-PRSP. p. 47.

Local Control versus Technocracy: The Bangladesh Flood Response Study. M Leaf - *Journal of International Affairs*, 1997 - [questia.com](http://questia.com) ... from the perspective of household and local organizations ... beneficiaries have crucial site-specific knowledge that the ... agreed on by the **Bangladesh** government and ...

Lorenz C.M. 1999. *Indicators for Sustainable Management of Rivers*. Thesis. Vrije

Mantel, S and Khan, M. F. A. (Eds) 2006. Chittagong Hill Tracts Improved Natural Resource Management. Report on the National Workshop held in Rangamati, Bangladesh 15 - 16 February 2006. CHARM Project Report 1.p.49.

Mendoza, G.A. 1997a. Introduction to the analytic hierarchy process: Theory and application to natural resources management. Proceedings: Joint Annual Meeting of the American Congress on Surveying and Mapping (ACSM); American Association of Photogrammetry and Remote Sensing (ASPRS), and Resources Technology Institute (RTI). April 5–10. Seattle, WA.

Mendoza, G.A. 1997b. A GIS-based multicriteria approaches to land suitability assessment and allocation. Proceedings: Seventh International Symposium on Systems Analysis in Forest Resources. May 28–31. Traverse City Michigan.

Messerli, B. 2001. From the Earth Summit 1992 to the International Year of Mountains 2002. In Mountains and People. p. 12-13. Burne, Switzerland, Swiss Agency for development and cooperation.

Mitchell, Bruce, 1990. "Integrated Water Management." In *Integrated Water Management: International Experiences and Perspectives*, ed. Bruce Mitchell. London, U.K.: Bel-haven Press, 1990.

Morris, William, ed. 1976. The American Heritage Dictionary of the English Language. Houghton-Mifflin Company, Boston.

MoWR, 2007. [www.mowr.gov.bd](http://www.mowr.gov.bd)

Mucleston, K.W. Integrated Water Management in the US. Chapter 2 in: Mitchell, B. 1990. NRET, 2001. Applying codes of practice in third world countries—what supermarkets can do to help. Available at [www.nri.org/NRET/supermarkets.pdf](http://www.nri.org/NRET/supermarkets.pdf)

Mustafa, M. 1996. The ecology and management of traditional homegardens in Bangladesh. Ph.D. Thesis. University of Wales, Bangor, U.K.

Mysiak, J., Giupponi, C. and Rosato, P., 2005. Towards the development of a decision support system for water resource management. *Environmental Modelling & Software*, 20(2): 203-214.

National Research Council. 1999. New Strategies for America's Watersheds. National Academy Press, Washington, DC.

Nath, T. K., Inoue, M and Myant, H. 2005. Small-scale agro-forestry for upland community development: a case study from Chittagong Hill Tracts, Bangladesh. *J For Res* (2005) 10: 443-452.

Niemeijer, D., 1996. The dynamics of African agricultural history: Is it time for a new development paradigm? *Develop. & Chang.* 27: 87-110.

Pramanik, 1994. Remote sensing Applications in Disasters Monitoring in Bangladesh. [www.gisdevelopment.net](http://www.gisdevelopment.net)

Payne, A.I., Sinha, R., Singh, H.R., Huq, S. 2003. A review of the Ganges Basin: its fish and fisheries, The second international symposium on the management of large rivers for fisheries, Phnom Penh, Cambodia, 11-14 February (<http://www.lars2.org/>).

Prabhu, R., Colfer, C.J.P., Venkateswarlu, P., Tan, L.C., Soekmadi, R. and Wollenberg, E. 1996. Testing criteria and indicators for the sustainable management of forests. Phase I. Final Report. CIFOR Special Publication. CIFOR, Bogor, Indonesia.

Prabhu, R., Colfer, C.J.P. and Dudley, R.G. 1999. Guidelines for developing, testing and selecting criteria and indicators for sustainable forest management. Criteria and Indicators Toolbox Series No. 1. CIFOR, Bogor, Indonesia.

Prabhu, R., C. Colfer, and R. G. Dudley. 1998. Guidelines for developing, testing and selecting criteria and indicators for sustainable forest management. CIFOR Special Publication.

Prato, T., 1999. Multiple attribute decision analysis for ecosystem management. *Ecol. Econ.* 30, 207–222.

Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Published on CD-ROM, ISBN: 978-0-9789478-0-4.

Qureshi, M. Ejaz and Harrison, Steve H. 2003. Application of the Analytic Hierarchy Process to Riparian Revegetation Policy Options. *Small-Scale Forest Economics, Management and Policy* 2(3):441-458.

Rahaman, M. M. Water versus power: Role of dams in geopolitics of Ganges basin. Water Resources Laboratory, Helsinki University of Technology, Tietotie 1E, P.O.Box: 5200, Fin-02015 HUT, Espoo, Finland. (E-mail: [mizanur.rahaman@hut.fi](mailto:mizanur.rahaman@hut.fi))

Rametsteiner, E., 2001. SFM indicators as tools in political and economic context: actual and potential roles. In: R.J. Raison, A.G. Brown and D.W. Flinn, Editors, *Criteria and Indicators for Sustainable Forest Management. IUFRO Research Series 7*, CABI Publishing, Wallingford, UK (2001), pp. 107–130.

River Morphology Monitoring and Prediction: ... 2.3.5 Flood Zoning and Risk Mapping for Floods in Bangladesh.

Rasul, G., Thapa, G. B., Zoebisch, M.A. .2004. Determinants of land use changes in the Chittagong Hill Tracts of Bangladesh. *Applied Geography* 24: 217-240.

Rasul, G., 2005; State Policies and Land Use in the Chittagong Hill tracts of bangladesh, Gatekeeper Series-119. iied, London

Reynolds, K.M. (ed.) 2006. Proceedings of the IUFRO Conference on Sustainable Forestry in Theory and Practice. Edinburgh, Scotland. 5-8 April 2005. Gen. Tech. Rep. PNW-GTR-688.

Roy, R. D., Mohsin, A., Guhathakurta, M., Tripura, P., Gain, P., 2000. The Chittagong hill tracts: Life and nature at risk, Society for Environmental and Human Development.p.121.

Salahi, A., 2002. Comments on Issue of Mountain development in the Republic of Korea with special reference to the utilization of Resource by Yeo-chang Youn /Eui Gyeong km/ Cheo-hoshon: 6- 10 May, Kathmandu, Nepal.

Saaty, T. 1995. Decision making for leaders: The analytic hierarchy process in a complex world. RWS Publications, Pittsburgh, PA.

Schmoldt, D. L and Peterson, D. L. 1997. Using the Analytic Hierarchy Process for Decision-Making in Ecosystem Management. WO/Ecosystem Management 7(15): 17-23.

SCS. 1994. The forest conservation program: Programme description and operations manual. Scientific Certification. Systems, California.

SGS Forestry. 1994. Assessors handbook, policy document and procedures manual. SGS Forestry, Oxford, UK.

Shackley, S., McLachlan, C., 2006. Trade-offs in assessing different energy futures: a regional multi-criteria assessment of the role of carbon dioxide capture and storage. Environ. Sci. Pol. 9 (4), 376–391.

Shoaib, J. U. 1997. Indigenous Technology Knowledge on soil and water conservation in hill districts of Chittagong. Proceedings on application of Indigenous Technology Knowledge for watershed management in Bangladesh, Kathmandu, Nepal.

SHED, 1998. Bangladesh Environment: Facing the 21<sup>st</sup> Century, P. Gain (Ed), Reports background and analyses on important environmental issues in Bangladesh to provide a context to understand the country and construct informed opinions, ISBN: 984-494-006, 306p.

Shahid, S.M., 1994. *Data Collection and Analysis of Land Degradation*, Bangladesh Report, Bangkok, Rapa Publication; 1994/3.

SRDI, 2006. Annual Report on Soil conservation and Management Centre from 1993 to 2006.p.5.

SRDI Manual(in Bengali), Bandarban Sadar Thana, Bandarban.p.116.

SRDI(Soil Research and Development Institute) Map, 1987

Steiguer, J.E. D. , Duberstein, J. and Lopes, V. 2003. The Analytic Hierarchy Process as a Means for Integrated Watershed Management. School of Renewable Natural Resources, University of Arizona, Tucson, AZ 85721. p.734-740

SCWMC(Soil Conservation and Watershed Management Centre), 1998 and 2000. Annual Review, SRDI, Bandarban.

Swart, R.-J and Bakkes, J.-A., eds. 1995. *Scanning the Global Environment: A Framework and Methodology for Integrated Environmental Reporting and Assessment*. UNEP/EATR.95-01; RIVM 402001002 Environmental Assessment Sub-Programme. Nairobi, United Nations Environment Programme.

Thapa, G. B. and Rasul, G. 2006. Implications of changing national policies on land use in the Chittagong Hill Tracts of Bangladesh. *Journal of Environmental Management, Volume 81, Issue 4, December 2006, Pages 441-453*.

Thomas, J and Durham, B., 2003. Integrated Water Resource Management: looking at the whole picture. *Desalination*, 156(1-3), pp. 21-28.

Thomas, J. S. 2001. Waterside: a decision methodology for water supply development, PhD thesis, RMIT University, 2001.

Tim , U. S and Mallavaram, S. 2003. Application of GIS Technology in Watershed-based Management and Decision Making. In Watershed Update July to August 2003, Vol 1, No. 5. University of Amsterdam. p6

UN, 2007. [www.un-bd.org](http://www.un-bd.org).p4.

UNDP, 2007. [www.undp.org](http://www.undp.org).bd

Vacik, H. 2005. Development and application of Decision Support Systems for silvicultural Planning and Decision making. In: Fondazione Eni Enrico Mattei in co-operation with UNESCO-ROSTE: International Workshop on “Success and Failure of Decision Support Systems for Integrated Water Resource Management”, 06-07. October 2005, Venice, Italy.

Vacik, H., Lexer, M. J. 2001. Application of a spatial decision support system in managing the protection forests of Vienna for sustained yield of water resources.. *For. Ecol. Manage.*, 143, 1-3, 65-76.

Vacik H., Wolfslehner B., Seidl, R., Lexer M.J. 2006. Integrating the DPSIR - approach and the Analytic Network Process for the assessment of forest management strategies.

Vargas, L. and Zahedi, F. 1993. Special issue. Analytic hierarchy process and its applications. *Mathematical and Computer Modeling* Vol. 17.

WARPO, 2006. [www.warpo.gov](http://www.warpo.gov).bd

Walker, D. H., Cowell, S. G. and Johnson, A. K. L. 2001. Integrating research results into decision making about natural resource management at a catchment scale. *Agricultural Systems* 69:85-98.

Watershed Planning Implementation Project Management Committee (PMC), 1997. Final report 1997: An Evaluation of Watershed Management in Ontario.

World Summit on Sustainable Development (WSSD), 2002. [www.freshwateraction.net](http://www.freshwateraction.net).

Weiss, C. 2002. Scientific uncertainty in advising and advocacy. *Technology in Society* 24:375.

Wikipedia, 2007. [en.wikipedia.org](http://en.wikipedia.org).

Yusuf, M. 2004. Health and Biodiversity in Bangladesh (Unpublished). BCSIR Laboratories,

Zaman, M. 2005. The Root Level Evolution, *Star Magazine*, Volume 4, Issue 58, August 12, 2005.

Zeid, K. A. and Afifi, S. 2006. Multi-Sectoral Uses of Water & Approaches to DSS in Water Management in the NOSTRUM Partner Countries of the Mediterranean. *Natural Resources Management*. CEDARE. Corso Magenta, 63, 20123 Milano (I), web site: [www.feem.it](http://www.feem.it), e-mail: [working.papers@feem.it](mailto:working.papers@feem.it)

## 9 Appendix

Design of Annex:

Aspects	MS-I	MS-II	MS- III	MS-IV	MS-V	MS-VI
Principles 1	1					
CIV	1.3, 1.4, 1.1.1, 1.1.2, 1.5, 1.2.1.1, 1.2.1.6	1.3, 1.3.2, 1.3.1.2, 1.2.1.1, 1.2.1.2, 1.2.1.3, 1.2.1.4, 1.2.1.6	1.2.1.4, 1.3.3, 1.1, 1.3, 1.5.4.1, 1.3.2, 1.4.1.1, 1.4.1.2	1.1.2.1, 1.1.1.3, 1.1.3.1, 1.1.3.3, 1.1.3.4, 1.2.1.1, 1.2.1.2, 1.2.1.3, 1.2.1.4, 1.2.1.6, 1.3.2.1, 1.3.2.2, 1.3.3.3, 1.3.3.5, 1.3.3.1, 1.5.4.5, 1.5.4.6, 1.5.3.2, 1.5.3.3, 1.5.3.4, 1.5.3.5	1.1.2, 1.2.1, 1.3, 1.2.1.5,	1.1.1, 1.1.2, 1.2.1, 1.3.1.3, 1.3.1.4, 1.3.2, 1.3.3.2, 1.3.3.4, 1.3.3.5, 1.3.3.7
Necessary activities	Activity 1, 10, 9, 7, 29, 31, 33	Activity 6, 7, 11, 31	Activity 14, 15, 16	Activity 1, 2, 3, 6, 7, 21, 22, 23,24, 25, 26,	Activity5, 6, 7, 14, 16, 20, 29, 31	Activity5, 6, 7, 41
Principles 2	2					
CIV	2.1, 2.2	2.1.2, 2.2.1.6	2.1.1, 2.1.2.2, 2.2.1.4, 2.1.2.3, 2.2.1.5	2.1.1.1, 2.1.2.1, 2.2.1.3, 2.2.1.5, 2.2.1.6	2.1.1, 2.1.2, 2.2.1.1, 2.2.1.3, 2.2.1.4	2.1.2.2, 2.1.2.3, 2.2.1.1
Necessary activities	Activity 6, 23, 25, 26, 34	Activity 12, 14	Activity31, 32, 34	Activity14 , 34, 42, 44	Activity14 , 31, 32, 36	Activity 42, 45
Principles 3	3					

CIV	3.1, 3.2, 3.3, 3.3.5.1, 3.3.5.2, 3.4.2.1, 3.4, 3.2.2.1, 3.2.2.2, 3.2.2.4, 3.4.2.2, 3.4.2.3, 3.4.2.4	3.2.1.1, 3.2.1.2, 3.2.1.3, 3.2.1.4, 3.3.5	3.1.1.1, 3.1.1.2, 3.1.1.3, 3.1.2.1, 3.2.1.4, 3.2.1.5, 3.2.1.6, 3.3.1.1, 3.3.1.3, 3.3.2.2, 3.3.2.3	3.1.1.3, 3.2.1.1, 3.2.1.3, 3.2.1.5, 3.2.2, 3.2.2.2, 3.4.2.4	3.1.1.1, 3.1.14, 3.3.1.1, 3.3.1.2, 3.3.1.3, 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.3.4, 3.4	3.1.1.1, 3.3, 3.4.2.1, 3.4.2.2, 3.4.2.3, 3.4.2.4
Necessary activities	Activity 4, 8, 27, 28, 43	Activity 16, 30	Activity 2, 14, 17, 18, 19, 28	Activity 6, 14, 22, 34	Activity 27, 28, 46	Activity 45, 46
Principles 4	4					
CIV	4.1.1, 4.3, 4.2.1, 4.2.2.1, 4.1.1.1, 4.1.1.2	4.1.1, 4.3.1.1, 4.3.1.3	4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.3, 4.2.1.2	4.1	4.1.1, 4.1.3, 4.2.1.4	4.1.1, 4.1.2, 4.1.3, 4.2.1
Necessary activities	Activity 14, 15, 18	Activity 12, 13, 30	Activity 12, 13, 30	Activity 22, 19	Activity 16, 17, 18, 28, 30, 42, 47	Activity 30, 16
Principles 5	5					
CIV	5.2.1, 5.3.2, 5.1.2, 5.3.1, 5.5, 5.6.1.7, 5.4.1.2, 5.1.2.1	5.5, 5.6.1.1, 5.6.1.3, 5.6.1.3	5.1.1.1, 5.2.1.1, 5.2.2.1, 5.1.3, 5.1.4.3, 5.3.1.3, 5.3.1.4, 5.3.2, 5.4.1, 5.4.2, 5.4.3, 5.5.1, 5.6.1.3, 5.6.1.4, 5.6.1.5, 5.6.1.6, 5.6.1.7	5.1.1.1, 5.1.3, 5.1.4, 5.2.1.1, 5.3, 5.4.1.1, 5.4.2, 5.4.3, 5.5.2.1	5.1.1.1, 5.1.3, 5.2, 5.3, 5.4, 5.5, 5.6	5.1.1.1, 5.1.2.1, 5.1.4, 5.2, 5.3, 5.4, 5.5, 5.6
Necessary activities	Activity 2, 3, 5, 6, 19, 31	Activity 32	Activity 5, 6, 7, 8, 15, 36, 37, 41, 42, 46	Activity 5, 6, 14, 34, 38, 44	Activity 5, 6, 14, 16, 27	Activity 34, 41, 42, 43, 44
Principles 6	6					
CIV	6.1.1.1, 6.1.1.6	6.1.1.6, 6.1.1.7, 6.1.2	6.1.1.1, 6.1.1.5, 6.3.1.2, 6.3.1.3, 6.3.2	6.3.2.1, 6.3.1.1, 6.3.1.2, 6.3.1.3, 6.3.1.4	6.1.1, 6.1.2, 6.3.1	6.1.1, 6.1.2, 6.3.1, 6.3.2
Necessary activities	Activity 21 or 12 or 17, 46	10, 34, 48, 37	Activity 10, 37, 46	Activity 10, 48	Activity 10, 48	Activity 10, 46