A STUDY OF WETLANDS AND THEIR ROLE IN GEOECOLOGICAL ENVIRONMENT OF THE BHOGDOI BASIN, JORHAT, ASSAM, USING REMOTE SENSING AND GIS

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ABSTRACT:

For conservation of biodiversity, control of flood, production of fish as well as other aquatic resources and to maintain ecological balance, wetlands play a significant role. The Bhogdoi river basin contains a large number of wetlands, which have been neglected resulting in their degradation. This paper presents a discussion on the wetlands of the basin and their role in geo-ecological environment. The wetlands and its surrounding areas have undergone rapid changes in respect of agricultural activities, human settlement and industrialization resulting in an imbalance in the wetland ecosystem within the entire Bhogdoi river basin. Considering all these aspects, an effort has been made to provide an information base on the changes in area, land use pattern, etc. of the wetlands in five different years, viz. 1974, 1990, 1998, 2001 and 2005 and their impact on the wetland eco-system using visual interpretation technique for LISS III (1998, 2005), Landsat TM (1990, 2001), Survey of India topographical maps (1974) supplemented by ground verification. A study using GIS tools reveals that there has been significant change in the areas of the natural lakes and ponds in between the years 1974 (16.698 sq km.) and 1998 (8.554 sq km.). The number of the wetlands has increased but the area has been decreasing for the natural lakes and ponds. It is also clear that cut-offs 1974 (8), 1998 (19) and 2001 (21) respectively have caused considerable changes in the channel alignment and channel morphology and there is an increasing trend in the development of meander loops in the Bhogdoi river. Similarly the length

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of the river during 1974, 1998 and 2005 were 184 km, 186 km and 191 km respectively. However, though the cut-off process has been active in the lower reach, the river does not show a shortening effect as the measurement for 32 years show that the length of the river has increased although there is an increase in number of cut-offs.

Keywords: Wetland, biodiversity, flood control, geo-ecological environment.

Introduction:

In the flood plains of the Brahmaputra and its tributary the Disai River are found a large number of natural lakes and swampy areas. The lake-like fresh water bodies are locally known as bils, whilst the swampy areas are variously called as 'Jalah', 'Doloni', 'Pitoni', 'Hola', etc. In certain areas, the bils are often called as 'Haor' or 'Gadeng'. All these natural features are included under the comprehensive term wetlands. Normally bils represent a vast sheet of water with varying shape, size and depth. Some of them are partly or fully infested with floating mats of aquatic plants. Reeds, grasses and bushes comprise the common natural vegetation in the shore areas of beels. The swampy and marshy areas, such as Jalah, Pitoni and Doloni, are shallower than the bils. They are normally developed close to river banks and on ageing shallow bils. Some of them are very extensive, although most are smaller in size. These wetlands are the home of a large variety of fauna and flora, especially the migratory birds.

The bils of the basin are traditionally used as natural fisheries, which are potentially rich in fish and other aquatic resources. The genesis and development of bils are closely related to the geomorphic and tectonic history of the region and hydrological characteristics of rivers.

High-resolution imagery from Landsat, SPOT and IRS series satellites provide basic information for different hydrological regimes and for water resources evaluation. The monitoring of wetland changes over time has been widely used within the scientific communities. Wetland change detection using remote sensing and geographic information system (GIS) technologies were proved to be powerful tools for evaluating the environmental conditions and human activities in different ecosystems.

Study Area:

The Bhogdoi River basin is situated within latitudes 26°15′N and 26°55′ N and longitudes 93°40′E and 94°30′E, falling within Jorhat and Golaghat districts of Assam and Mokokchung and Wokha districts of Nagaland, covering around 2,521 sq. km of area (Fig. 1). The Jorhat and Golaghat districts comprise a vast stretch of alluvial plain in the west, south and north and the Mokokchung and Wokha districts comprise of a strip of Naga Hills in the entire southeastern side. The river course is highly meandering and develops many ox-bow lakes.

The climate is hot and humid during summer and cool in winter. The daily mean temperature is about 27° C during the summer and 18° C during the winter. The average annual rainfall is 2044.99 mm (Jorhat Development Authority Report-2004). The prevailing patterns of weather and climate have a strong bearing on the occurrence and intensity of flood hazard in this region.

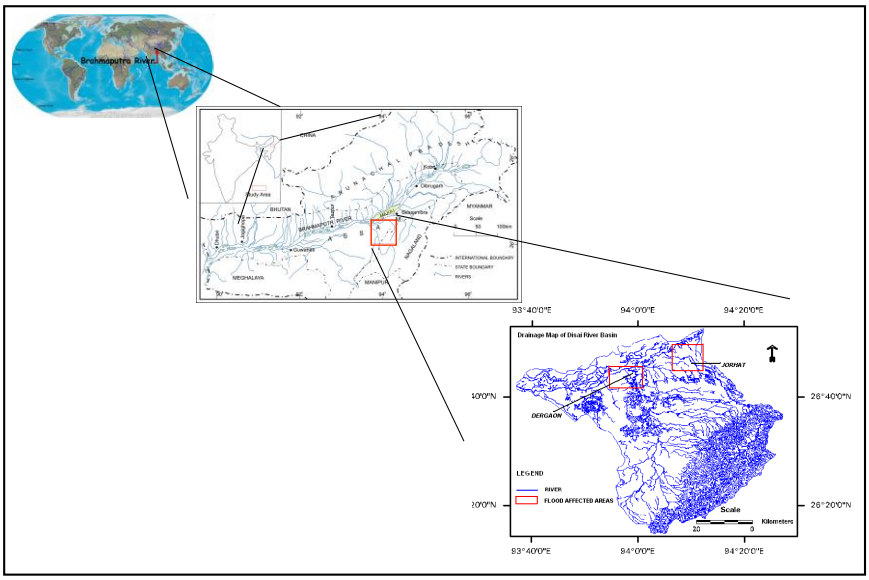

Fig. 1 Location map of the study area.

Previous work:

The Geological Survey of India has periodically (e.g. 1981) carried out geomorphological study of the Brahmaputra basin. Rates of erosion and bankline migration of the Brahmaputra in Assam had been studied by Naik & Singh (1996), Naik et. al. (1999), Sarma (2002), Gilfellon et al. (2003), Sarma (2004) and Sarma and Phukan (2006). Kotoky and Sarma (2001) carried out a study on hydrogeomorphological features of a part of the Brahmaputra in Assam. Sarma et. al. has studied the bankline ratio of the Burhi Dihing river in Assam. Borthakur (2005) has worked on geochemical aspects on the Disai river basin.

Data Base and Methodology:

The data base used in the present study comprise a subset of each of the Landsat Thematic Mapper (TM) in 28.5 m spatial resolution acquired in 1990 and 2001 and IRS 1C/1D LISS III FCC in 24 m spatial resolution acquired in 1998 and 2005 and also Survey of India Topographical Maps 83 J- 1, 2, 3, 4 and 5, 83 F- 13, 14 and 15 in 1:50,000 scale of 1974, were used for delineating the wetlands and detection of their changes with time.

All the digital images were geometrically rectified to facilitate their comparison, which were georeferenced to Polyconic map projection and Everest ellipsoid using ERDAS Imagine software. The resultant root mean square error (RMSE) was less than 0.5 pixels, indicating an excellent registration. The nearest neighbor resampling method was used to avoid altering the original pixel values of the image data.

Result and Discussion:

As many as 733 number of wetlands have been identified in the Bhogdoi river basin using satellite imagery and topographical maps of 1:50,000 scale (Fig.2). The shape, size and area of the wetlands are delineated from satellite images, which are supplemented by field observations.

The data presented in Table-1 reveal that natural wetlands such as lakes and ponds take the lion's share of the total geographical area under wetland category, followed by swamps and

marshes with 6.09 sq km. The ox-bow lakes, which play a major role in production of fishes and other aquatic economic resources, covers around 1.12 sq km.

Table-1

Distribution of different types of wetlands in the Bhogdoi River basin.

Wetland type	Number		Area (in sq. km)	
NATURAL	**1974**	**1998**	**1974**	**1998**
Lake/pond	55	62	16.698	8.554
Ox-bow Lake/Cut-off Meander	13	17	1.388	1.125
Swamp/Marsh	23	47	6.637	6.098
MAN - MADE				
Reservoir & Tanks	518	607	1.110	1.631

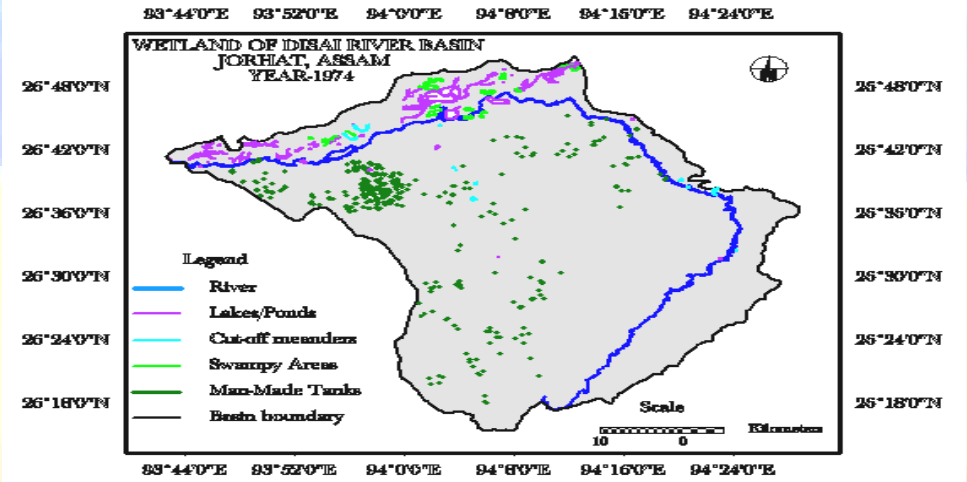

Fig.2 Different types of wetlands in the Bhogdoi river basin.

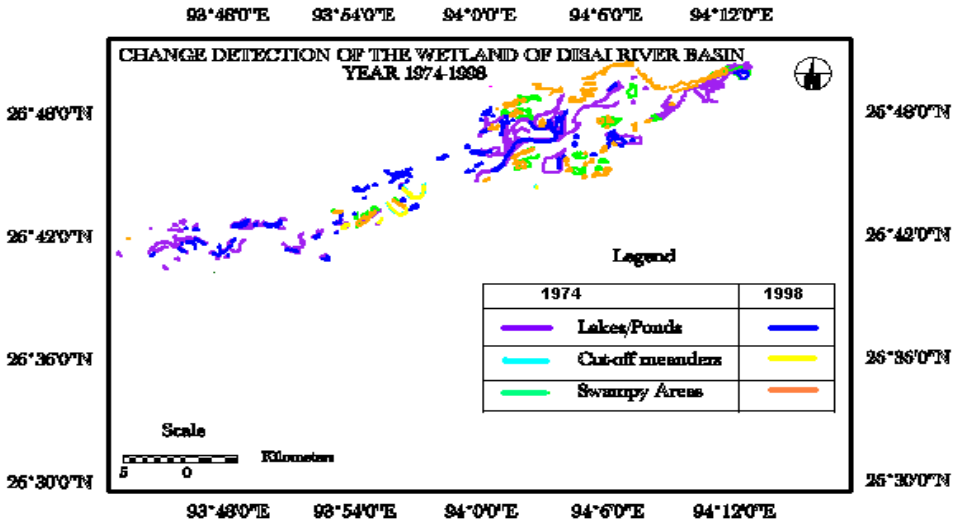

Fig. 3 Wetlands in the Bhogdoi river basin in 1974 Survey of India Toposheet and 1998 IRS 1C LISS-III imagery.

From Table 1 and Fig. 3 it is clear that although the number of lakes and ponds are increasing, the area of coverage is decreasing due to degeneration of the natural lakes of which many have changed to swampy areas.

The morphological study of the wetlands indicates that these wetland had formed due to various causes. The configuration of bils in the basin is divided into four categories, viz. linear, compact, irregular and ox-bow shaped (Fig. 4).

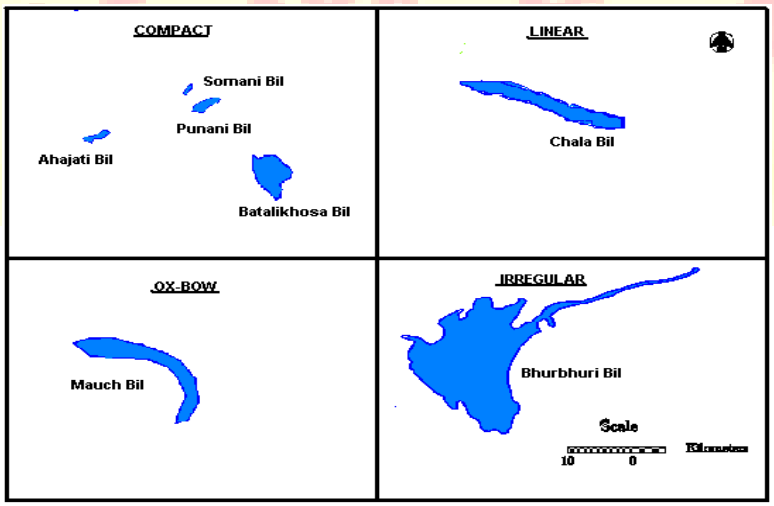

Fig. 4 Example of different types of bils according to their configuration in Bhogdoi river basin (Based on LISS III, 1998)

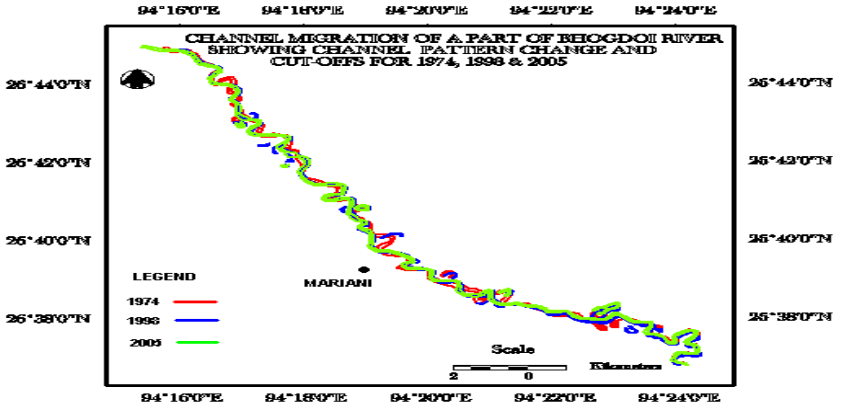

Fig. 5 Channel migration and meander cut- offs of a section of the Bhogdoi River between 1974, 1998 and 2005.

Development of channel cut-offs and ox-bow lakes

Meander cut-offs are commonly occurring floodplain features that record the channel conditions at the time of abandonment. Abundant cut-offs and sinuous paleochannels in the Bhogdoi basin plains are suggestive of local movement through lateral bank erosion due to tightening of meander loops until cut-offs occur. The present study in the Bhogdoi plains also indicates that the development of cut-offs is not necessarily very sudden; this is reflected by comparing the channel morphology from topographic maps and satellite images of different period. It is, however, clear that cut-offs have caused considerable changes in the channel alignment and channel morphology of the river Bhogdoi (Fig. 5).

Some of the cut-offs in the study area have resulted in ox-bow lakes due to rapid plugging of the necks of the cut-offs by sediment. These ox-bow lakes are being filled gradually, depending upon the nature and availability of sediments, mostly by overbank flows from the adjoining channel. The factors controlling sedimentation in ox-bow lakes vary spatially and temporally. However, dominance of fine clay and organic-rich sediments is obvious, giving rise to very dark

grayish green tone on the satellite images (Fig: 6), clearly distinguishable from bluish tone of flowing clear water in the active channels.

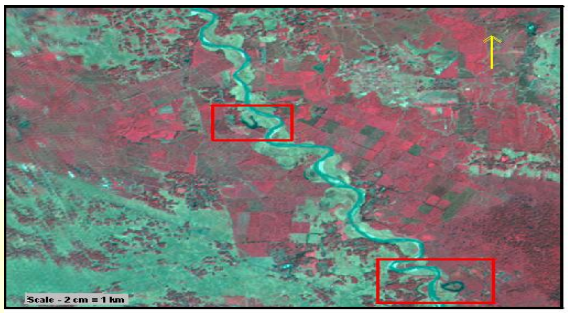

Fig. 6 Ox-bow lakes giving rise to very dark grayish green tone on the LISS-III 1C/1D image- a part of Bhogdoi River.

Formation and changes of bils and other wetlands in the study area depend on geomorphological processes as well as environmental changes. Environmental changes are not necessarily natural; rather such a change may take place because of the human interference at various levels. Broadly, the formation processes of all category wetlands are divided into two (i) autogenic and (ii) allogenic. The autogenic process is related to the river regime, i.e., channel migration, loop formation, neck cut-off, etc. On the other hand, allogenic processes include various types of human interference. The wetlands in the study area are formed mainly by the hydraulic action of rivers. The entire Bhogdoi valley, except for the southeastern Naga Hill ranges, is a flat plain with a very gentle slope. In this part, the gradient is less than 2°. As soon as the river and its tributaries debouch into the plain from Naga Hills they become sluggish and develop meandering pattern. As a result many cut-off meanders and oxbow lakes have formed in this part of the region (Sharma and Goswami, 1993).

The allogenic changes that take place mainly because of human activities are responsible for formation of many bils and swamps in the basin. Major changes are observed in the river regime after the commissioning of regulatory works on rivers. Construction of embankments for flood control and irrigation has been causes drastic changes in the river course, thereby altering the wetland environment in recent years. In addition, the decreasing forest cover in the entire

basin is also significantly affecting the flow regime and the denudation pattern of rivers, accelerating the siltation rate of the river as well as of bils and swamps.

The details of the areas under built-up land, land use / land cover categories and the areas under different forest and plantation categories within the Bhogdoi river basin are shown in Fig. 7 and Fig.8. The vector layer has been prepared from Survey of India topographic maps on 1: 50,000 scale of the year 1974. The classes using LISS III 1998 imagery were first generated by the unsupervised classification based on spectral properties, taking Isodata algorithm with hundred classes (100), iteration ten (10) for accurate classification. Then merging the likely five (5) classes in Signature Editor Table. After getting the required classes a Supervised Classification was performed using the edited unsupervised Signature File, taking Non-parametric rule as parallelepiped, overlap rule as parametric rule, unclassified rule as parametric rule and parametric rule as maximum likelihood. Final classified map is compared with the arc coverage layer prepared showing land use from SOI toposheet and change detection was found out.

It has been found that there is substantial increase in the built-up land (418.24 sq. km 1974 and 1101.67 sq km in 1998) in the entire Bhogdoi River Basin. In the upper catchment of Bhogdoi and Kakadonga rivers also it is observed that there is an increase in the built-up land resulting in depletion of forest cover in the Naga Hills, thereby confirming an increase in the population in the upper catchment. In the plain areas also, there is an alarming increase in the built-up land resulting in a decreasing trend in the open space and degeneration of wetlands.

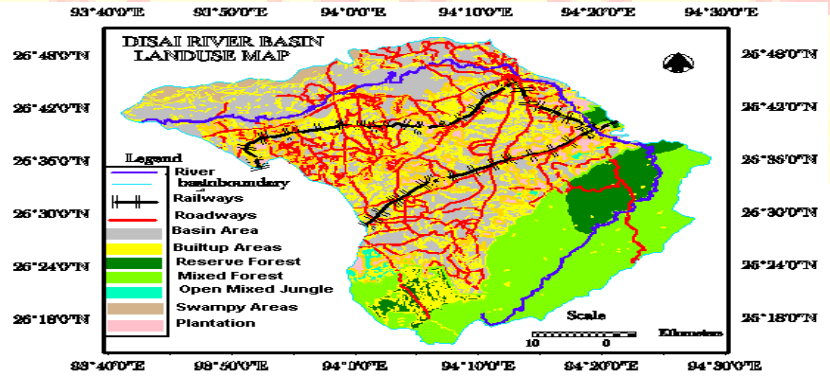

Fig. 7 Arc Coverage Land use layer prepared from SOI Toposheet (1974)

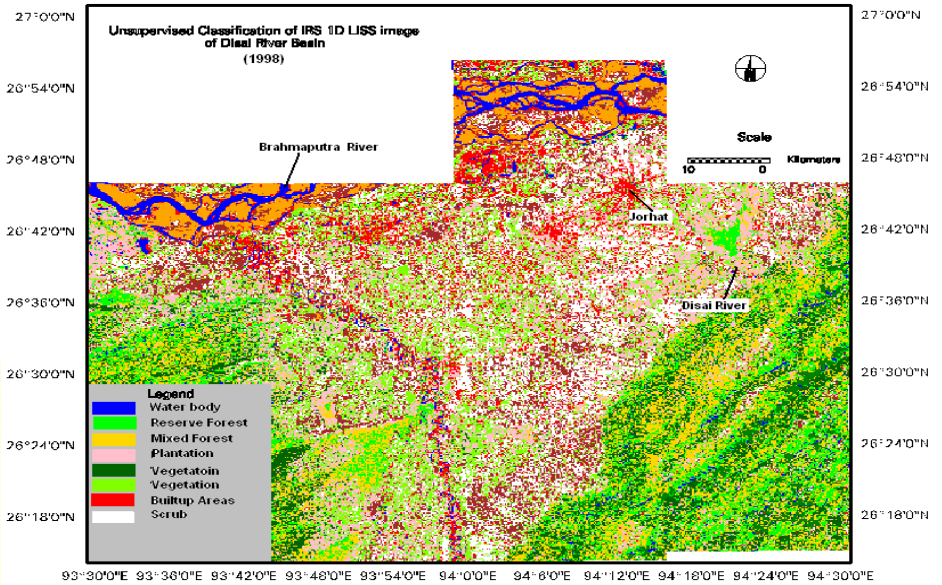

Fig. 8 Supervised Classification of IRS 1D LISS III (1998) to detect Landuse Change

Channel pattern represents a mechanism of channel adjustment through natural processes of lateral shifting as well as meandering. Meandering is one of the means through which rivers, mostly in alluvial terrains, tend to attain a quasi-equilibrium state. A dynamic equilibrium is maintained by lengthening of the river courses through meandering and bankline migration which is again compensated by a self shortening process affected by cut-offs of overdeveloped meanders.

As for the present study, to evaluate the channel pattern changes of the Bhogdoi River, satellite data have been used which are supplemented by maps and toposheets.

The number of cut offs in the year 1974 as found in the topographic maps from source to the mouth of the Bhogdoi River was eight (8), which increased to nineteen (19) in 1998 and to twenty-one in 2005. Similarly the length of the river during 1974, 1998 and 2005 were 184 km, 186 km and 191 km respectively. However, though the cut-off process has been active in the lower reach, the river does not show a shortening effect as the measurement for 32 years show that the length of the river has increased with an increase in number of cut-offs due to the development of new meander loops.

Table. 2

Name of the River	Source of Data	Year	Length Measured	No. of Cut-off
Bhogdoi	SOI Toposheet (1:50,000)	1974	184 Km	8
	LISS III 1C/1D (resolution 24 m)	1998	186 Km	19
	LISS III 1C/1D (resolution 24 m)	2005	191Km.	21

The channel shortening owing to meander cut-off or lengthening owing to intensification of meander loops causes significant changes in the slope and flow pattern of rivers. As a result, the formation of new ox-bow lakes/bils and degeneration of the existing ones are induced. The wetlands of the basin are extremely significant from the point of view of controlling the intensity of flood during monsoon season. The wetlands help in reducing flood height and thus flood damage as they act as buffer zones for rivers and other waterways during the period of heavy rains. As the siltation of the bil bottoms is becoming a serious problem leading to the degeneration of these water bodies, the sediments should be trapped in the catchments areas through afforestation.

Conclusion:

The study indicates that since 1974 till date condition of the wetlands of the Bhogdoi River Basin have been deteriorating due to various anthropogenic and natural factors. The wetlands are losing their effectiveness as a natural reservoir that controls the hydrology of the surrounding region. Due to faulty landuse practices and the discharge of many variety of domestic and other professional wastes from the Jorhat city is making the wetland environment critical for a large variety of aquatic flora and fauna.

The threats to the river basins are indeed great and calls for immediate intervention in the form of integrated river basin management solutions. Establishing environmental laws, improving water allocations and rights, improving efficiency in water use and minimizing impacts where

infrastructure are unavoidable, are some of the steps that can check the degradations being perpetrated on the river basins.

It is also essential to value the cost to human and wildlife health when calculating the economic feasibility of proposed development. Measures for protection of watersheds and wetlands from destruction, improved enforcement of pollution laws, fishing regulation etc., are urgently required. Pollution can be curbed through better management practices for production of crops and livestock. A mechanism for overall integrated basin management with involvement of diverse stakeholders and effective wetland management authorities is critical to sustainable use of river basin resources. In these way diverse interests including fisherman, farmers, government agencies and environmental groups can create long-lasting partnerships that are essential for developing a common vision and solution for natural resource use and conservation in river basins.

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