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PLANNING STRATEGY FOR INTEGRATED WATERSHED MANAGEMENT IN THE LOWER JIADHAL RIVER BASIN OF ASSAM, NORTH-EAST INDIA

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ABSTRACT

The environmental problems of the upper and lower basins of Jiadhal river are different but interrelated. Integrated watershed management trigger to mitigate natural hazards including land degradation, soil erosion, floods, sediment transport, siltation and sedimentation. It includes the integration of many scattered programs of soil conservation, afforestation, minor irrigation, crop production, tree plantation, fodder development and other development activities into a well prepared watershed project. These are mainly based on climate, land, water and plant resources on the one hand and man and animal resources on the other. Therefore, it offers hope for bringing about sustainable development and management of natural resources. The study area selected for the study is a part of lower basin of Jiadhal river which is a phenomenal river system with lots of sediment carrying capacity and intensive flood frequencies making it havoc for the inhabitants of the areas it drained. The phenomenon of siltation by sediments brought down by the river system from the upper basin is the real cause of the situation of the degradation of the agricultural land, land use pattern as well as the socio- economy of the population dwells in the lower Jiadhal Basin. Thus, the paper includes the study of environmental geomorphology and highlight the serious land degradation and to propose planning strategy for Integrated Watershed Management of the Lower Jiadhal River Basin of Assam, north east India.

Key words: Environmental degradation; Sub basins; Planning strategy; Integrated watershed management;

I. INTRODUCTION

A watershed is a topographically delineated area that is drained by a river system, it is also a hydrological unit, a biophysical unit and a holistic ecosystem in terms of the materials, energy, and information that flow through it (Wang, 2016). Watershed management is a continuous process involving the management of natural as well as social aspects of a watershed. The interaction of human over the natural environment is the main force behind these innovative concepts of natural resources management. Integrated Watershed Management is one of the products of the man-nature relationship. Watershed management is the consequence of the continuous observations and empirical analysis of the natural phenomenon occurring in a geographical unit in spite of the diversities in respect of the environmental geomorphology, integrated watershed management builds upon the foundational principles of watershed management to integrate various social, technical and institutional dimensions, as well as conservation, social and economic objectives (German, 2007).

Watershed development means, incorporates the ultimate or optimal use of land, water, plants and animals as well as conservation of natural resources within the geographical unit by human being. Watershed management tries to maintain the balance between the natural resources on the one hand and human being on the other with a concerned plan to cope with the diversities within. It includes the natural calamities, land use / land cover, landslides, soil erosion as well as agricultural output, which also provides a wider range of allied activities like horticulture, sericulture, dairy, fisheries and agroforestry which owes the economy of the region. Integrated

watershed management triggers to curve an integrated plan to sustain and enhance watershed functions that provide the goods, services and values desired by the community affected by a watershed boundary (Rawat, 2011, 2014). The management is complex, including components within the watershed (e.g. upstream, midstream, downstream) and even beyond involving human and natural sectors.

OBJECTIVES

The following are the objectives of the research

1. To identify the sub-catchments of the Lower Jiadhal Basin.
2. To study the environmental and geographical aspects of Lower Jiadhal Basin
3. To propose a comprehensive planning strategy for integrated watershed management for the lower Jiadhal river basin.

II. METHODOLOGY

The paper concerns the environmental geomorphological studies of the Lower Jiadhal River basin, flowing from the hilly terrain of the Arunachal Himalayas to the extensive plain of Assam particularly of Dhemaji District in Assam. A field observation method was applied for the fulfillment of objectives of the study followed by technical use of reparation of maps and comparisons with the help of Geographical Information System GIS and Remote Sensing software and images for the analysis. Case study and survey were conducted in the selected sensitive areas for the ground truth. Primary data were collected in the field through observations, interviews, case history method etc. The secondary data were collected from the various documents, journals, news paper, reports and records published by the state government and others agencies.

For the selection of the area flood history of the area was considered with reference to Cartosat DEM of the area from Bhuvan, ISRO open source (C1_DEM_16B_2006-2008_v1_94E27N_g46e). The delineation of watersheds was done considering the DEM, and further subdivided to catchment areas. Land Uses / Land Cover maps were prepared with the multispectral images downloaded from USGS portal (L71135041_04140051110_MTL) for the same area for strategic planning of the basin for the natural calamities like floods and widespread siltation. Google earth engine was used for the identification of the remote places followed by field observations.

STUDY AREA

The study area selected for the research is a river basin of district Dhemaji, Assam, which is havoc in the form of river system. Jiadhal river covers an area of 1851.43 km^2 having latitudinal and longitudinal extensions of 27º 08’ N to 27º 45’ N and 94º 15’ N to 94º 38’ E respectively. Out of its total basin area 1851.43 km^2, Arunachal Pradesh occupies 370.63 km^2 i.e. 20 % of the total basin area and rest 1480.80 km^2 i.e. 80 % of the basin area drains to the state of Assam. The basin is adjacent to Moridhal river basin in the east and Subansiri river basin in the west. Rising from the West Siang district of Arunachal Pardesh or Siang formations at an elevation of 1247 m and the area receives an annual rainfall of 3,500 mm as receded (Gogoi and Chetia, 2011).

The Jiadhal basin is mainly delineated in consideration of the physiographic division of the river basin into Upper particularly dominated by high mountainous terrain with identical environmental geomorphology which separate it from the lower river basin - a feature less extensive flood plain. Various natural hazards were observed in lower basin in relation to the drainage morphology and this paper triggered to understand the environmental geomorphology and the strategic plan were formulated for the sustainable development of lower basin areas following Gogoi (2015).

III. RESULTS

The following sub-catchments were identified and studied in detail.

1. Na-Nadi Catchment: Na-Nadi catchment is the northern most catchment along the southern slope of the Arunachal Himalayas with Subansiri basin in the western margin and enclosed by the Jiadhal catchment from east and southward. The Na-Nadi has a perimeter of 77.51 km with a drainage area of 192 sq. km.
2. Jiadhal Catchment: The Jiadhal flow south west direction, towards the west it is bordered to Subansiri basin and each catchment joins from the east. It has an aerial extension of 626 sq.km with a perimeter of 244.11 km.
3. Koran Nadi Catchment: The Koran catchment is between Jiadhal and Charkaria catchments in its west and east respectively and the northeast margin is bordered with Moridhal basin. It has a perimeter of 140.72 km with area of 266 sq. km.
4. Charikaria Catchment: It has an aerial extension of 228 sq.km with a perimeter of 126.31 km. The north and west margin touches Koran catchment and towards the east lies the Brahmaputra basin and the south part shares with Chila catchment.
5. Chila Nadi Catchment: The smallest catchment of the lower Jiadhal basin lies to the south east and bordered with Brahmaputra basin along its eastern margin. It has an aerial extension of 169 sq.km with a perimeter of 73.9 km.

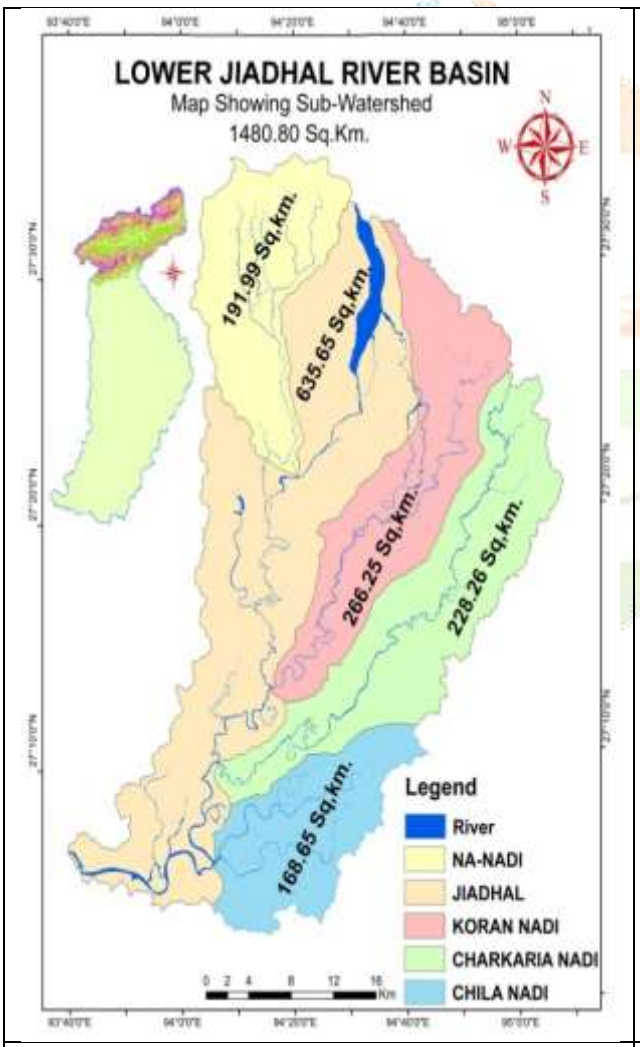

Fig.1. : The Sub-catchments of Lower Jiadhal Basin.

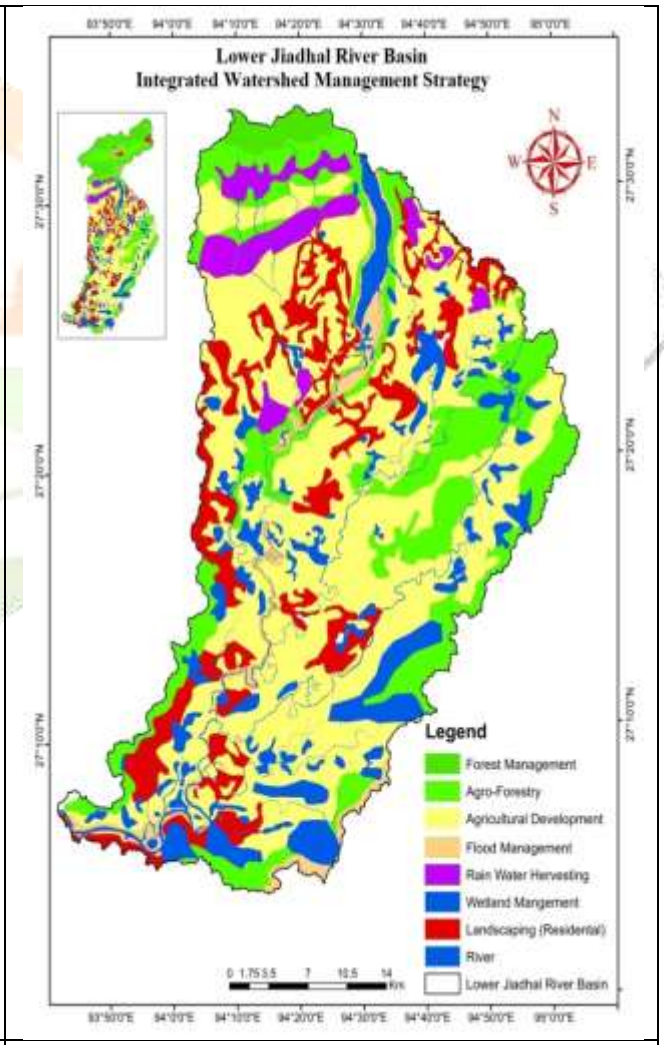

Fig.2: Integrated Watershed Management strategy for Lower Jiadhal River Basin

Table No. 1: The Geographic characteristics and Watershed Management attributes of the Sub- watersheds of the Lower Jiadhal Basin.

Sub-Watershed	*Environmental aspects*	*Physiography (%)*	*LU/LC (%)*	*Aspects of Management planning*
Na-Nadi	Flood, Water logging, Fluctuating water table	Piedmont (6), Highlands (2) rest is plain ranging from 50-250 meters	Dense forest -2, Degraded forest-22, Bare soil-exposed -4, Rural Dev-14, Fallow land-28, Net Sown-28 and Wetland-1.	Flood management, Structural measures- Embankment and river bank, Wetland Management, Rain or Surface water harvesting
Koran	Water logging, Bank erosion	The topography is more or less homogenous with loss range of altitude ranging from 50 to 250 meters .	Bare soil-exposed-10,Rural Dev-33, Fallow land-18, Net Sown-3 , Wetland-5 and Water body-2	Wetland Management, Agricultural development, control top soil erosion, river bank protection measures, surface water harvesting
Charikaria	Flood, Water logging, Fluctuating water table,		Sand-Silt-4, Bare soil-exposed -17, Rural Dev-34, Fallow land-14, Net Sown-18, Wetland-11 and Water body-4.	Wetland Management, Agricultural development, control top soil erosion, river bank protection measures, surface water harvesting
Chila	Water logging, Fluctuating water table, seasonal drying		Sand-Silt-3, Bare soil-exposed -20, Rural Dev-20, Fallow land-10, Net Sown-16, Wetland-22 and Water body-9.	Improve stream flow, Wetland management, Flood management, Improving transport facilities
Jiadhal	Siltation, Sedimentation, Sallow river depth, Bank erosion, Embankment bleaching, Unstable river course, River shifting, Flood, Water logging, Fluctuating water table		Sand -Silt-2, Bare soil-exposed -15, Rural Dev-32, Fallow land-14, Net Sown-25, Wetland-8 and Water body-3	Flood management, Structural measures- Embankment and river bank, Wetland Management, Maintenance of river flow, Drainage interlink management, Rain or Surface water harvesting, Agricultural development, Control top soil erosion, River resource utilization-sand quarry promotion, Landscaping of residential areas, Improving Transport facilities,

IV. DISCUSSION

Sub-Catchments of Lower Jiadhal Basin:

The Jiadhal Drainage System that drains the study area is a young mountainous river system originated in the hilly terrain of Siwalik Himalaya of Arunachal Pradesh particularly the West Siang District. The basin is adjacent to lower eastern mountainous part of Subansiri River, and later it drains as its largest tributary in the plains of Assam. The drainage basin or watershed of Jiadhal river has the areal extension of 1851.43 sq.km. The drainage basin is divided into two geographical units mainly due to the physiographical differences in comparison to the drainage system prevailing as, Upper Jiadhal Basin and Lower Jiadhal Basin.

The Upper Jiadhal Basin is extended in the hilly tracks of Arunachal Pradesh and has a rough terrain with bisected river system. The stream dissected the terrain in numerous ridges and isolated with different drainage characteristics. The Jiadhal Upper Basin consists of 370.63 sq.km of aerial extension. The mapping indicated the highest width of the basin recorded as 38.07 km. from east to west and 18.48 km from north to south extent. Comprising mainly three tributaries joining together and the Jiadhal originated from the Tri-Junction.

The Lover Jiadhal Basin is associated with piedmont areas and flood plain produced by the active drainage system. The river course is associated with siltation problem due to low slope gradient. The elevation generally ranges from 50 to 250 meters from msl and towards the north the altitude rises to 800 meters along the Arunachal Himalayas. It is compiled of numerous drainage system which is interlinked in many cases and comparatively five major sub-watershed have delineated. The river course is turbulent in the upper basin and flows through a deep gorge to the extensive plain. It is sallow in the plains and often flowing above the altitude of adjoining areas or the flood plains in the northern part of the lower basin. River braiding is common phenomenon during dry and in wet season river shifting due to failure or bleaching of embankment is common. The low lying areas of the lower basin are always remained water logged and have permanent wetland or swamps. During wet season the water level of

the river as well as the agricultural fields get affected, which ruins the agricultural yields greatly. The socio-economy of this area is greatly influenced by the natural calamities flood hazards in the watershed, including high rate of siltation and sedimentation, soil erosion, water logging, fluctuating water table and floods.

Geographical Aspects

The environmental geomorphology of the lower basin is mainly dominated by the extensive flood plain with gentle slope gradient. The composition is mainly old and new alluvium, with feature less flat topography. The main characteristics of river course of the lower basin is widespread siltation, sedimentation, sallow river depth, bank erosion, embankment bleaching, unstable river course, river shifting, flood, water logging and fluctuating water table. The Jiadhal lower watershed is the most affected area accompanied by hazardous floods and siltation problems thus, strategy for watershed management is the need of the hour for sustainable development of the study area. Thus its management is mainly triggered the flood hazard management measures, structural measures-embankment and river bank, wetland management, maintenance of river flow, drainage interlink management, rain and surface water harvesting, agricultural development, control top soil erosion, river resource utilization-sand quarry promotion, landscaping of residential areas and improvement of transport communication. The region receives heavy rainfall during summer and cloud burst is common phenomenon, increasing the river flow during rainy season, and in dry season the water level reduces to nominal. The range of water level is extreme which ranges 15-16 meters of height as the recorded data of the Water Resource Department of Dhemaji, Assam.

The Jiadhal sub-watershed is the largest of all having 626 sq.km of aerial extension and covers 42% of the lower Jiadhal basin (Table.1). Dominating land use is the rural development areas comprising 32%, and net-sown area of 25% followed by bare soil-exposed of 15% and fallow land of 14% of the Jiadhal sub-watershed. It has 8% areas covered by wetland and 3% of area by water body thus the most demanding aspect of management are flood management, structural measures- embankment and river bank, wetland management, maintenance of river flow, drainage interlink management, rain or surface water harvesting, agricultural development, control top soil erosion, river resource utilization-sand quarry promotion, landscaping of residential areas, improving transport facilities. Koran sub-watershed is the second largest with 266 sq.km of extension covering 18% area of the lower basin. Rural development areas cover 33% of area, followed by fallow land with 18% and bare soil-exposed of 10% with prior management aspects are wetland management, agricultural development, control top soil erosion, river bank protection measures, surface water harvesting. Charikaria extended 228 sq.km comprises 15% of the lower watershed area with 34% area under rural development area, 18% by net-sown area followed by 17% of area under bare soil-exposed. It consist 11% of area under wetland and 4% under water body so most dominating aspect of watershed management are wetland management, agricultural development, control top soil erosion, river bank protection measures, surface water harvesting. Na- Nadi sun-watershed in the northern part is extended 192 sq.km and covers 13% of the lower watershed. It has relief variance and 6% is piedmont areas with elevation of 500 m above msl and 2% highlands elevated to 800 m above msl. It has 22% degraded forest and 2% of dense forest cover along the northern terrain and plains down consist of 28% areas each under net-sown and fallow land and 14% of rural developed area. The main aspect of management is flood management, structural measures-embankment and river bank, as water logging is the trigger to be managed by wetland management, rain or surface water harvesting measures. Chila sub-catchment comprises 169 sq.km and 11% area of the lower Jiadhal watershed and mainly dominated by wetland extending 22% of the sub-basin followed by 20% of rural development area. Thus the main aspects of watershed management concentrates on improving stream flow, wetland management, flood management, improving transport facilities as to cope up with flood like situation due to water logging (Table.1).

Proposed Planning Strategy

Among the earlier proposed management techniques for control of floods and soil erosion in lower basin particularly the flood plains, the structural measures are found to be effective for longer durability. The most popularly used structural designs are the flood embankment, spurs, bank revetment, and structural compositions like porcupines and dikes along the triggered areas. Considering environmental geomorphological and land use land cover analysis, the management plan evolved for lower Jiadhal basin is as follows (Fig.2).

Forest Management: This category of management plan includes the afforestation of the degraded forest cover, and to retain the natural vegetation compiling the sustainability of soil, slope and forest ecology. The resources from forest are collected occasionally, and would be continued too, thus the species should be preserved and replenished in the natural habitat so that the biodiversity would sustain. Local people participation in Public Private Partnership should be encouraged in ground level so that the need of forest management is understood by the local population and work for it by their will. Indigenous knowledge of forest based industries should be supported for socio-economic growth through forest replenishment (Fig.2).

Agro Forestry: The plan includes the replenishment of degraded bare land, sand and silt casted land along the river course which are unproductive, introduction of agroforestry. This will be benefiting both environmental geomorphology of the basin and the socio-economy of the basin too. As the lower basin is favorable for sericulture, so plantation of plant species fit for sericulture would solve the problem. Horticulture is another option which not only enriches the environment but also sustains the economy of the population inhabiting the area.

Agricultural Development: The share of fallow land is increasing, which ruined the interest of agriculture in larger scale. Proper innovative plans should be initiated in agriculture to use the land resource to its ultimate, to boost the economy of the basin area. Fluctuating water table and unpredictable monsoon are the hurdles in irrigating agricultural fields which cause seasonal unemployment of arable land. Drainage linking programmes could solve the problem of irrigation and agricultural land could be benefited.

Flood Management: Permanent solution to flood problem is the construction of structural measures for longer durability. Earthen embankments as suggested by CWC (2011), and RWD, Dhemaji could solve the problem if the top of the embankment are concerted to metallic road. Small structural measures to retain river course and bank erosion should be adopted. River deepening by authorized and systematic quarrying of sand resources from the river bed is beneficial both for the smooth river flow and in the landscaping of the adjacent low lands. Proper road transport to the river side for heavy trucks and loaders is the only requirement along the enablement in selective sites of sand quarry (Fig.2).

Rain Water Harvesting: The solution to fluctuating water level for agricultural purposes and soil conservation could be resolved by rain water harvesting in headwater catchments of the lower basin. The integrated watershed management programmes would solve to problem if it is correlated to alternate occupations for local inhabitants as fish and poultry farming, so that the local population could get economic benefit of it too (Fig.2).

Wetland Management: The water logging in low lying areas always ruined the arable land as well as settlement areas during heavy rainfall in the lower basin area. The wetland management programme could solve the issue for the biodiversity of the basin. The wetland should be treated and renovated so that they accommodate the excess surface runoff, and could be used for economic as well as ecological benefits too.

Landscaping (Residential): The range of elevation of the lower Jiadhal basin is very less. The agricultural land and even residential areas are below the river bed, which creates the water logging phenomena in rainy season. Such areas could be renovated to raise land by landscaping, and the government schemes of rural road connectivity could be benefited by aborting innovative plans considering the river deepening as well as landscaping of vulnerable sites (Fig.2).

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