Rural Hydrological Environment of a Floodplain Village in the Brahmaputra Valley, Assam: Status, Changes and Livelihood Issues

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Submitted by

Manash Jyoti Bhuyan

Regd. No.: 074742 of 2012-2013

Under the Supervision of

Dr. N. Deka

Department of Geography,
Gauhati University, Guwahati-14
Assam, India

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DEPARTMENT OF GEOGRAPHY

Gauhati University

Gopinath Bordoloi Nagar, Guwahati-781014, Assam, India

Dr. N. Deka
Assistant Professor

Phone No. : +917002741406
E-mail: nityageog@yahoo.co.in

CERTIFICATE

Certified that Mr. Manash Jyoti Bhuyan, an M.Phil student in the Department of Geography, Gauhati University has completed this dissertation entitled "**Rural Hydrological Environment of a Floodplain Village of the Brahmaputra Valley, Assam: Status, Changes and Livelihood Issues"** under my guidance and supervision. It is submitted in partial fulfillment of the requirements for the degree of Master of Philosophy of this University. He has fulfilled all the requirements laid down in the M.Phil regulations of the University.

The dissertation is the result of his bonafide work and personal investigation in the field and consultation of various sources of information and ideas. The matter embodied in this dissertation has not been submitted to any other University/Institute for the award of any degree or diploma.

Date : 17/08/2018
Place : Guwahati

(N. Deka)

GAUHATI UNIVERSITY

DEPARTMENT OF GEOGRAPHY

DECLARATION

I, Manash Jyoti Bhuyan, hereby declare that this dissertation entitled **Rural Hydrological Environment of a Floodplain Village of the Brahmaputra Valley, Assam: Status, Changes and Livelihood Issues** submitted to the University of Gauhati for partial fulfillment of the requirements for the award of the degree of Master of Philosophy (M. Phil) is the result of my own work carried out under the guidance and supervision of Dr. N. Deka, Assistant Professor, Department of Geography, Gauhati University.

The matter embodied in the dissertation has not been submitted by me for any other degree to this university or any other university/institution.

Date : 17/08/2018

Place : Guwahati (Manash Jyoti Bhuyan)

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CONTENTS Page No.

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

1.1 Statement of the Problem

The concept of 'rural hydrology' has emerged in the field of geography in the later part of 20th century to study the hydrological environment of the village landscapes of a region and their impact on the concerned physical settings and human societies and vice-versa. This concept has been taken as an approach in the field of geographical research to understand and investigate the evolution, mechanism and components of hydrological environment. Although different hydrological parameters need to be examined to understand the hydrological environment of an area, however in geographical research this concept is recently applied by some geographers to study the hydrological systems and their characteristics, utilization patterns and management practices of water resource, nature of human adaptation and the impact of hydrological environment on human societies and ecological settings, especially within a micro-rural setting. 'The rural hydrology approach, a form of "alternative engineering", requires a feet to walk around, an eye to see the real environmental conditions, an ear to listen to those who are informed of the local conditions, and a flexible mind to share with local people, in order to identify land and water conditions, constraints to development, and the real needs of the locality and local people' (Uchida, *et.al,* 2005). It is a holistic approach to carry out a comprehensive study on the evolution of rural systems and their basic characteristics as determined by water dynamics. Rural hydrological approach can be considered very important to mitigate many rural ecological and economic problems which have recently emerged as a result of some irrational developmental activities, such as construction of roads, railways, embankments, and also for the haphazard extension of settlement by ignoring and disturbing the natural hydrological settings molded basically by the pattern of surface flow and channel runoff, wetlands, nature of precipitation, ground water status, etc.

The State Assam is a mosaic of rural landscapes. The rural landscapes are characterized by the abundance of diverse water bodies or in other words, the rural landscapes are made diverse by the existence of different types of wetlands, such as man-made pond (*pukhuri*), natural pond (*khal*), *beel*, marshes (*pitoni*), swamps (*doloni*), dead channel (*morasuti*) and rivers. It is important to note that the rural life and livelihood of the Brahmaputra valley have been revolving around farming, animal rearing and fishing activities (Deka and Bhagabati, 2010). In these contexts of the rivers, wetlands, flood water level on the paddy fields, direction of surface run off etc. play an important role. The micro-variations in elevation of the paddy fields differentiate the water level and thereby determine the land use pattern. Based on the elevation of lands and water level, various types of crops are practiced in different seasons. The settlements and other extensional activities have also expanded based on the existing hydrological settings. The flow of surface runoff influences the field pattern and the depth of water level and duration of retention of water in the wetlands, thus define the typology of wetlands. Therefore, the study of rural hydrology is highly important in order to understand the micro-topographical settings and land use pattern of an area.

The Brahmaputra valley of Assam expanding for a length of 720 km (Taher and Ahmed, 2014) and an average width of 80 km (Deka, 2012) is characterized by diverse topographical settings and water dynamisms. It is endowed with numerous large and small wetlands of different shapes and sizes. According to Assam Remote Sensing and Application Centre (ARSAAC), 10123 sq. km. of Assam has been occupied by wetlands accounting for 9.7% of the total geographical area of the State (Phukan and Saikia, 2014). Although the valley apparently exhibits relief, less alluvial plains have micro level variations in relief characteristics, which have led to the development of varied landscapes and waterscapes.

It is noteworthy that, earlier people of different ethnic groups started making their settlement near the source of water. Therefore, human settlements were developed on the banks of the rivers and around some prominent wetlands of the Brahmaputra valley. Thus, all the activities of the people were dependent on the hydrological conditions of the valley. It should be mentioned here that, the Brahmaputra valley is mostly dominated by rural landscapes. Thus, land use pattern and land cover status of the valley are mainly determined by the rural hydrological situations. The soil, topography, vegetation, agriculture, wetlands and micro-climatic conditions are basically governed by the rural hydrological environment. However, the people living in the villages of the Brahmaputra valley have off late observed some changes in the rural hydrological system caused of many natural and socio-economic factors. Due to subsidence of ground water levels in some places of the valley, the water of wells goes down or in some cases completely dries up during the winter season. Even, the tube wells cannot pump out water during this season because of which several water related problems have popped up. The rural hydrological system comprises the status, functions, mechanism and the intrinsic relationship of different types of wetlands and water concentrated areas and their role towards the production systems, biological diversity and human culture in the rural areas of a region. . These wetlands are the micro-aquatic ecosystems, which contribute directly to the local environment and the rural economy as well.

It is noteworthy that people started inhabiting in the Brahmaputra valley 5000 years before present (Barpujari, 2004, Choudhary, 1987). The primitive people, dwelling in different parts of the valley, maintained a harmonious relationship with its varied ecological and hydrological settings. However, over time, the rapid growth of human population in the valley with the concomitant development of settlements on the one hand and the progression of urbanization, industrialization and large scale infrastructural activities on the other have caused tremendous pressure on the valley's rural hydrological scenario. Besides, destructions of forest cover, unplanned construction of roads and houses, practicing agriculture by clearing forests, etc. are some of the factors, which have directly or indirectly affected the rural hydrological situation of the valley. Thus, there has been noticed a change in processes of evapotranspiration, rainfall patterns and distributions and temperature conditions, etc. which has ultimately disturbed the water cycle system. The status of the rural hydrological environment of the valley is thus, no longer the same and has been changing over time under the influence of such anthropogenic pressure. Due to the changes in rural hydrological conditions, the farmers of the valley have also changed the cropping pattern and practice in order to adapt to its changing rural hydrological conditions. It is also disheartening to note that with the changes in rural hydrological settings, the rural ecological situations as well as the rural economic conditions of the Brahmaputra valley have to face notable changes, which have ultimately caused serious impact on the life and livelihoods of the villages of the valley.

The Brahmaputra Valley civilization can be considered as an aquatic civilization as the people of the valley basically started inhibiting on the banks of the river Brahmaputra and its tributaries and also around some prominent wetlands. The evolution of the village landscape is centered to the hydrological environment of the valley as water determined the course of livelihoods of its rural people. Even today, the entire production systems of the Valley are mainly based on the availability of water. It is important to note that people of different ethnic groups have inhabited in different parts of the valley by adapting to the varied physical settings. As water is most essential to human lives and the rural people in many parts are still lacking in running water facilities both for drinking and irrigation purposes onto the agricultural lands, so the rural people have developed a kind of adjustment with the existing hydrological situations in order to sustain their livelihoods. Thus, it is seen that because of the variations in human response to the valley's varied hydrological environments within its different physiographic zones, a diverse mosaic of cultural landscapes have been witnessed which are enriched by different land use patterns, house types and settlement patterns. However, very recently it has been noticed in the floodplains of the Brahmaputra Valley that the hydrological environment has much been disturbed and degraded by some unplanned, inappropriate and unwise developmental activities as a result of which the rural ecological and economic conditions of the Valley have been seriously disturbed.

Although the rural hydrological conditions have been gradually deteriorating in the valley under the influence of many physical and anthropogenic factors resulting lot of problems, but they still hold great prospects in terms of resource potentiality in rural areas and livelihood sustainability of villagers if these can be properly managed from the perspective of sustainable development. Importantly, as the hydrological environment is intrinsically associated with the development of diverse landscapes and production systems in rural areas, therefore, proper attention should be given to the concerned hydrological environment while designing and implementing plans and policies for rural development. Keeping these points in view, the present study has been undertaken to investigate the status and changes in rural hydrological environments and their impact on the life and livelihoods of the people of a floodplain village, called Kahargaon within the broad geographical framework of the Brahmaputra valley in Assam.

1.2 Objectives of the Study

The main objectives of the study are –

i. To study the status, functions and changes in the rural hydrological environment (RHE) of the village.

ii. To analyze the impact of rural hydrological environment on the life and livelihoods of the villagers on the one hand and the rural ecological conditions on the other.

iii. To examine the problems and prospects of rural hydrological conditions in the context of changing physical and socio-economic conditions of the valley.

iv. To suggest measures and action plans to mitigate some recently occurred physical and social problems caused by the changing RHE in the Brahmaputra valley in general and the village in particular in order to make the village environments of the valley sustainable.

1.3 Research Questions

The study is designed to be carried out around the following research questions:

i. What is the present status of hydrological environments in the village and how do the physical settings of the village influence the mechanism of rural hydrology and vice versa?

ii. How does the rural hydrological environment influence the life and livelihoods of the villagers on the one hand the ecological conditions of the village on the other?

iii. In what ways the rural hydrological conditions have been changing over time under the influence of changing socio-economic and physical conditions?

iv. How did the people adopt the micro physical settings within the village that are determined by the hydrological conditions and how have they adapted to the changing hydrological environments for sustaining their livelihoods?

1.4 Methodology and Database

The village Kahargaon has been selected in order to make a thorough investigation of its hydrological conditions and their changes and impact on the villagers. Different hydrological components of the village were studied on the basis of field investigation, site seeing, and field surveys through well designed questionnaire cum schedule. Relevant secondary data were collected from various secondary sources, consultation of maps and relevant books and journals. The required secondary data/information were procured from various government sources, like Primary Census Abstract and Raha Revenue Circle Office, Government of Assam.

The village was intensively surveyed through different types of primary survey, viz. household survey, *dag* survey and wetland survey to have a clear picture on the existing hydrological conditions of the village. With the help of GPS, the latitudinal and longitudinal positions of the village were obtained and the elevations in different parts of the village from the mean sea level were recorded. Based on its latitude and longitude, the village was found to be located on the south bank floodplain of the Brahmaputra valley.

1.4.1 *Dag* Survey and Mapping

The village has been surveyed in detail through plot (*dag*) survey (Deka and Bhagabati, 2010) to get a vivid picture of the land use pattern and land cover status of the village. The *dag* map was obtained from Raha Revenue Circle Office of Nagaon district, Assam. In the field, with the consultation of the land owners and the *mandal,* the data/information about land use pattern and its changes, status of land cover, flood level on the fields, water level and its variations in the wetlands in different seasons, soil quality, etc. were collected. Based on this data, some of the thematic maps of the village have been prepared.

A detailed land use map was prepared with the help of *dag* map and ground truthing. Some of the components of landscape and mainly of waterscape of the village, like man-made ponds (*pukhuri)*, natural ponds (*khal*), settlements, different types of agricultural lands (*khetimati)*, grazing lands (*bakorimati*), fallow land (*sonpora* mati), etc. were identified and drawn on the map.

The agricultural fields of different types and the cropping patterns were also identified by field observation and also by interviewing with the land owners of the village. The agricultural land use maps in both summer and winter season were prepared.

Again, by observing the cuts in the levees (*dags*) of the paddy fields, pattern of surface water flow including the input and output systems of water within the village has been found out and drawn on a map. The pattern of surface flows has been shown with the help of arrows indicating their directions of flow and thus, a model of the hydrological system of the village has also been shown.

1.4.2 Household Survey

The study is mainly based on the primary data/ information obtained by surveying all the 291 households of the village through a well-designed questionnaire. The relevant data on demographic structure, size, distribution and number of the wetlands, year and purpose of digging the *pukhuris,* year of installing tube wells and ring wells, water level of the wells, tube wells, different wetlands and agricultural fields, ground water status, traditional water related knowledge and belief systems were collected from the field survey.

Fig. 1.1: Household survey

Again, area under different crops of each household has been found out based on which area under different crops and cropping intensity in each *chuburi* has been estimated. Besides, size and distribution of agricultural landholdings and area under different crops in the village as a whole and production of different crops in the village were also collected during the field survey.

The changes in wetlands and field hydrology, water uses and aquatic ecosystem have been inquired and noted down after ground truthing. The changing nature of interaction of people with the wetlands and their utilization has been found out. On the other hand, the problems and impacts of the hydrological conditions in the village on both humans and ecology were consulted with the members of the households. Thus, the number of species of animals and plants which have been decreasing over time has also been recorded.

Along with it, the mode of human adjustment to the hydrological conditions that existed in the past and that exists today is quite different as people have adopted different strategies and methods to adapt to the changing hydrological conditions of the village.

To understand the general background of the village, various cultural practices (festivals, linguistic, food and dress habits, etc.) and economic characteristics (agriculture, occupational structure, poultry, dairy, transport and communication, etc.) that prevail in the village have been found out through the household survey.

1.4.3 Water Quality Analysis (WQA)

Water Quality Analysis (WQA) has been done by collecting water samples from each type of wetlands and also from the tube wells and ring wells in each *chuburis* (hamlets) to assess some hydrological parameters (Fig. 1.2). For this purpose, some wetlands, tube wells and ring wells have been randomly selected in each *chuburis* for collecting water samples. The parameters selected for water quality analysis have been considered as important in order to understand the present status of ecological conditions of the wetlands.

Fig. 1.2: Collecting water samples from different sources

1.4.4 Water Level Measurement

For measuring water level of the wetlands such as *pukhuris* (man-made ponds), *khals* (natural ponds), *Kalong*, *Mora-Kolong*, etc. bamboos with scales marked on it have been fixed in different types of wetlands in each *chuburi*. Thus, the water levels of the wetlands in each month have been recorded through this traditional method. Again, there has been a marked difference in water levels in the sunlight-prone and shadow-prone wetlands. So, bamboos have also been dipped into both sunlight-prone and shadow-prone wetlands (*pukhuris* and *khals*) to find out their differences of water levels.

Fig. 1.3: Measuring water level of wetlands

1.4.5 Other Methods

The information regarding the use of water resources were collected from the members of the village and the village head (*gaon-buha)*. The methods of Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) were applied for appraising the problems and prospects of different components of the rural hydrological system. Some focus groups discussions (FGDs) among the people belonging to different age-sex groups, and occupations as well were conducted to acquire concerned information and their perception towards the changes in waterscape and hydrological conditions in the village and their impact on people's livelihood and village's ecology.

Again, oral interviews were also conducted among the age-old persons of the village to know about the origin and etymological meaning of the village, evolution of settlements, hydrological conditions during their days.

Contours on the village map were drawn on ArcGIS 10.2.1 with the help of ASTER DEM data to examine the slope pattern in the village in order to relate it to the surface flow pattern.

Some meaningful cartographic and statistical techniques were applied using Microsoft Word, Microsoft Excel, Google Earth Pro and ArcGIS 10.2.1 both for processing and representing the data so obtained in the form of tables, maps and diagrams.

1.5 Review of Relevant Works

Although, a large number of works have already been done in the field of hydrology, wetlands and rural landscape at different levels by hydrologists, geologists, geographers and other scholars, but only few works have been carried out on rural hydrology till date. Though some studies on urban hydrology have been carried out by different researchers, work on rural hydrology are still very limited.

Wetland Hydrology

Simply, hydrology means the systematic and scientific study of the distribution, movement and water quality, which also includes the mechanism of water cycle, water resource potential and watershed sustainability.

Hope *et al.* (2004) in their study in Luvuvhu catchment of South Africa tried to focus on the link of rural livelihoods to the hydrological cycle. The work in the Luvuvhu catchment is basically based on household questionnaire survey among four communities. However, secondary data are also used. The paper assimilated the links between the rural livelihoods, land use changes and the services and goods provided by both blue water (aquifers and river water) and green water (soil moisture from precipitation, used by plants via transpiration). Furthermore, the study tried to show the impact of the pattern of land use on poverty aspects as a means of knowing the policy development. The policy development here associates with forestry, land affairs, institutional governance, agriculture etc., in a practical and integrated approach.

Lee *et al.* (2013) put forwarded a study on the spatio-temporal characteristics of the flow of small rural streams in order to investigate and analyze the status of stream depletion located downstream of irrigation reservoir. Here, Bonghyun and Hai reservoirs and each downstream were selected for the study purpose. The results of the study showed that the stream depletion was mostly found in the downstream of reservoir for both irrigated and non-irrigated periods. It was also found that where there were few stream flows, the vegetation covers the stream and blocks the stream flow, further hampering in its original function.

Hession *et al.* (2003) in their work entitled "Influence of bank vegetation on channel morphology in rural and urban watersheds" indicated that the channels in urbanized watersheds are wider than channels in the non-urbanized watersheds and the effect of riparian vegetation is independent of the level of urbanization. The study was based on the morphology of the streams in the piedmont region of United States.

Uchida has made some pioneering works on rural hydrology in different countries of Asia. Uchida *et al.* (2005) have jointly reviewed and published a paper entitled "Rural Hydrology: An Alternative Approach To Rural Infrastructure Build –Up in Bangladesh Rural Development". The authors proposed a "rural hydrology" approach for investigating and planning of rural infrastructure build –up in the flood plain zone of Bangladesh. Their focus was to use the term rural hydrology as a practical proposition for rural development in less developed countries. The authors stated that "we can use the terminology of engineering hydrology for the technological approach and the terminology of rural hydrology for interview approach".

Asada (2011) in his book "Climate and Rice Cropping Systems in the Brahmaputra Basin: An Approach to Area Studies on Bangladesh and Assam", has discussed clearly about the relationship between hydrological environment and rice cultivation in Rangpuria gaon in Lakhimpur district of Assam. He further investigated the relationship between rainfall variation and hydrological environment in the paddy fields and the influence of hydrological environment on rice yield. He also analyzed the changes in cropping technology and its adaption to the changing hydrological environment.

Uchida and Ando (2007) in their study on Jawar village of Bangladesh tried to evaluate the traditional agricultural techniques owing to the water level in the paddy fields. They have mentioned about the classification of lands by the farmers into *boro jami* or *shail jami* and *kanda* on the basis of the hydrological conditions that prevailed in the village. Besides, they brought into light the adaptive agricultural system to dynamic water condition in R*abi* and Aman T. variety.

Uchida and Ando (2007) studied the pattern and practice of *boro* rice in different fields using different sources of water for irrigation during the dry season. They carried out their study in Jawar village of Bangladesh.

Chieng (2003) studied the climatic conditions and water use in the paddy fields where the author has proposed some salient environmental functions of paddy agriculture.

Sembiring *et al.* studied the water management of crops in Indonesia. They have suggested two main strategies of improving water management in food grain agriculture. Besides, they observed that the crop rotation pattern is adjusted to the availability of water.

Cole *et al*. (1997) in their work entitled “Wetland hydrology as a function of hydrogeomorphic (HGM) subclass”, (1997) stated that “characterising wetland hydrology is key to assessing relative function over a range of wetland types”.

Carter (1996), studied on the formation, persistence, size and function of wetlands, and said that all these aspects are highly related with the hydrologic processes. The wetland soils and vegetation also alter water velocities, flow paths and chemistry. Moreover, the researcher viewed that the hydrological and water quality functions of wetlands are deeply related to the physical set up of wetlands.

McCartney *et al.* (2011) discussed the combination of land cover and hydrological conditions in Ga Mampa wetland of South Africa. They focused on the livelihoods and economic provisioning services put forwarded by the wetlands. In the context of livelihood analysis, Sustainable Livelihood Approach was undertaken, wherein data were collected through a mix participatory tool.

Price and Waddington (2000), put forwarded a study on Canadian Wetland Hydrology and Biogeochemistry. They estimated that 14% of the total land area of Canada is covered by wetlands, and these wetlands have considerable impact on water run - off and storage, atmospheric exchanges of carbon, water quality etc. However, many wetlands of the country have been suffering from resource exploitation, ecological degradation and water and soil contamination. Such situations have seriously impaired its ecological functions. This paper reviews the current hydrological research in all types of Canadian wetlands, and methods like field and laboratory observations and modeling studies are incorporated in the study. The hydrological processes as mentioned in their study include surface and groundwater flow, run off, evaporation, micro-climate, water balance, exploitation and restoration water bodies.

Another important study on wetland hydrology was put forwarded by Sun *et al.* (2001), where they examined the hydrologic impacts on various common forest management practices. These practices basically included harvesting, site preparation and drainage. Field hydrological data collected during the past 5-10 years from 10 forested wetland sites across the southern US are synthesized, by using various methods. These include Hydrologic Simulation Models and Geographic Information Systems. The hydrologic variables used in this assessment included parameters like water table levels, drainage and storm flow on a spatio-temporal scale. The study focused that wetland ecosystem have higher water storage capacity and also higher evapotranspiration, compared to that of uplands. Secondly, a conceptually generalized model is also developed in order to illustrate the relative magnitude of the hydrological effects of forest management on different types of wetlands. The model further suggests that, climate is an important factor in controlling wetland hydrology.

Cole *et al.* (2000) carried out a detailed investigation on the patterns of wetland hydrology in the ridge and valley province of Pennsylvania, USA. They found that the ground water dominated wetlands (riparian depression and slopes) were the wettest sites while the surface water systems (headwater and mainstream floodplain wetlands) were drier.

Kazezyilmaz *et al.* (2007) studied the beneficial aspects of constructed wetlands. However, appreciation to the importance of restored wetlands in terms of best management practice, in order to improve the water quality of storm water runoff, has been given importance very recently. Secondly, investigating groundwater interactions within wetlands is acknowledged as important in order to get a clear-cut analysis of the effects of wetland hydrology on water quality.

A detailed study on the indigenous typology of wetlands in a village environment was carried out by Deka and Bhagabati (2015). They investigated the pattern of distribution of different types of wetlands and their functions and utility in a village located in the floodplain of the Brahmaputra Valley, Assam.

Water Quality Analysis

The aquatic ecosystems are an important part of our environment and they help in maintaining water quality. Criteria like mineral content, dissolved metals and turbidity are used to assess the quality of water.

LaDon Swann (1997) tried to portray an analysis on the importance of water quality in aquaculture. He focused that water quality determines the success or failure of an aquaculture operation to a great extent.

Singh (2013) while describing environmental degradation and pollution in India in his book, "Environmental Geography", gave much emphasis on the criteria of pollution of river water in India. He stated five classes (A, B, C, D and E) for identifying the water quality. Here each class has been assigned different criteria for indicating water quality.

Similarly, Todd in his book "Groundwater Hydrology" (1980), stated about the analysis of chemical, biological and physical characteristics of groundwater, where he used the trilinear diagram for representing the analysis of groundwater quality (after Hem). Besides he also incorporated the water quality criteria in terms of drinking water, irrigation and industrial water.

Belt *et al.* (1992), in their article -"Design of forest riparian buffer strips for the protection of water quality: analysis of scientific literature", analyzed the design of stream protection zones (SPZ s), which is a best management practice in order to protect water quality on timbered stream reaches in Idaho. The request for this study came from the Director of the Idaho Department of Lands (IDL).

Hounslow (2018), in his book, "Water Quality Data: Analysis and Interpretation", primarily emphasized on the interpretation of water analyses, with major applications and concern upon groundwater pollution or contaminant transport.

The work on “Regional and global concerns over wetlands and water quality”, carried out by Verhoeven *et al.* (2006), focused on the status of water quality of stream catchments and river basins. The paper highlighted on the aspects of water purification functions of wetlands at the site and catchment scale.

Novotny (1994), stated that subsurface migration, fertilizer runoff from farms, storm water from streets and other diffuse pollution have caused serious environmental consequences. Moreover, in most cases in which water quality goals are not achieved, diffuse pollution appears to be the main cause. Here the aspects of diffuse pollution cover the arena from sources and sites to health and legal consequences. The author provides a base of an integrated approach in dealing with water quality control and also explains the advanced pollution abatement technologies, such as the use of wetlands.

Johnston (1991) in his research work on “Sediment and Nutrient Retention by Freshwater Wetlands: Effects on Surface Water Quality” focused on the mechanisms of freshwater wetland interaction with sediments and nutrients. In this context the study stated that the mechanisms vary in magnitude and reversibility and even differs with respect to wetland types. They include litter decomposition, sedimentation and retention in soil, plant uptake and most importantly microbial processes.

Ibekwe *et al.* (2006) examined the “Impact of Plant Density and Microbial Composition on Water Quality from a Free Water Surface of Constructed Wetland”. They clearly shows the evidence that wetlands which are composed of 50% plant cover, may help in promoting the growth of diverse microbial communities. These communities further facilitate decomposition of chemical pollutants in surface water, and improve water quality.

Banerjee (2013) in her doctoral thesis entitled, “Geochemistry of Groundwater in the North Western Part of Burdwan District, West Bengal with Special Emphasis on Drinking and Irrigation Qualities”, has dealt with the drinking water suitability, in terms of both chemical and microbiological constituents. She further used Water Quality Index (WQI) for showing the overall quality of water in the study area. Moreover, the temporal variation of WQI is also observed here. Secondly, she also discussed about the irrigation water suitability in the area, taking into account the parameters like salinity, toxicity, permeability etc.

Giri (2011) in his work carried out a study on physio-chemical and biological parameters, in order to assess the water quality in and around Thimphu area of Nepal He assessed water quality on the basis of seasonal variation of the parameters, especially on pre-monsoon, monsoon and post monsoon season.

Another significant study on water quality analysis was put forwarded by Sophia Barinova (2017). The study interpreted that the quality of water should be both assessed and predicted.

Sugam *et al.* (2018), put forwarded a study on the status of traditional water bodies of Meerut district, inorder to help the government in initiating necessary steps, for the protection of such water bodies. Here the study incorporated a field based research, which involved on-ground survey using GIS mapping, GPS and even water quality testing of 120 ponds. Moreover, an informal discussion was put forwarded around for 500 residents, located nearby ponds. The results further showed that more than 50% of water bodies are severely polluted. The major problems are eutrophication due to excessive nutrient pollution and sewage contamination.

Water Resources and their Utility

Wetlands can be considered as one of the most important natural resources. The valuation level of wetlands can be stated as supreme in context to other ecosystem forms, which consider aspects like shoreline erosion control, flood protection, natural water filtration and improving water quality, together with opportunities for recreation and nature appreciation. They provide places to canoe, birdwatcher, photography, fishing and even providing natural scenic vistas for the artists.

Historically, throughout the world, wetlands have often been considered as wastelands because they appear to be wet, muddy areas that breed flies, diseases and unpleasant odor.

According to Joy B. Zedler and Suzanne Kercher (2004) the estimates of global wetland area range from 5.3 to 12.8 million km^2. The fact underlined here is that changes in the quantity and quality of the world's wetlands cannot be tracked adequately. Biodiversity support, carbon sequestration, flood abatement etc. are some of the key functions that are impaired when the wetlands get degraded.

Several works on the resource utilization of wetlands have been put forwarded with respect to specific areas. Works on the role of wetlands resource utilization on community livelihoods of Songwe River Basin, Tanzania carried out by Kalisa *et al.* (2013) focused on the pattern of resource utilization and its significance in supporting rural livelihoods. The study shows that 81.7% and 85.6% of the sample population in Kutumbasongwe and Mpunguti village respectively depended largely on wetland resources. These included basically rice production, fishing and harvesting of macrophytes for weaving, livestock keeping etc. The resource utilization patterns have been towards the expansion of rice production and settlement at the expense of other land cover types. Methods like structured questionnaires, participatory methods and remote sensing techniques were used in addressing the study.

Another significant case study of community utilization of wetland resources is the study on Agu wetland, Kumi district of Uganda (School of Forestry, Environmental and Geographical Sciences Collection [297]). The study shows that poorest households are more engaged in wetland activities and there also exist a positive correlation between the levels of poverty and level of wetland utilization activity. Here a cross sectional research approach was used to collect data from 102 households who were actively involved in the utilization of wetland resources. Data's were collected by the use of questionnaires, and focused group discussions. Agu wetlands have contributed to rural livelihoods in terms of food security, animal grazing, brick makings, fishing and harvesting papyrus.

Mthiyane *et al.* (2009) in their work "Small Scale Farming on Wetland Resource Utilization: A Case Study of Mandlazini, Richards Bay" stated that – "Wetlands resources restoration involves a complex web of myriad of interactions that take into account local knowledge acquisition from both non-formal and formal education. In the process, these forms of knowledge construction seem to be missing analysis from a socio-cultural viewpoint, which may strengthen understanding of impacts of activities arising from the local community's general dependence on wetland resources". The qualitative research base here incorporates the socio cultural impact of the people of Mandlazini regarding how they use the wetlands with respect to the use of indigenous knowledge in order to restore the wetlands. However, structured questionnaires, participatory methods were also used in studying the area. The study also revealed that these areas are one of the most productive resourceful areas that can provide food and other non-aquatic resource base and also retains a balanced ecological base for the local residents. Other areas of beneficial associates with crop cultivation in the wetlands, crafts and woven construction from plants, production of craft sleeping mats from wetland plants, thatching grass for houses, beer strainers, reed harvesting etc.

The Ramsar Convention is the only single treaty that focus on one type of ecosystem i.e., the wetlands. The Convention defines wise use of wetlands as “the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development”.

Scodari (1990) stated that both the use and non-use values are linked with wetlands where the aspects of use values are generally connected with direct use values such as fish production and other aquatic flora and fauna.

In view of various wetland services, many researchers have tried to identify the management strategies of wetlands for society in particular. Haq *et al.* (2005) focused on the aspect of soil less agriculture that acted as an alternative source of livelihood in the Central South-western part of Bangladesh. Here the productivity of wetland is based on a special kind of farming is higher compared to the terrestrial agricultural and is also supportive to open water fisheries.

Mbaiwa (2003) further explained the dependency level or status and also the development of enclave tourism in the Okavango Delta, Botswana, Nyakaana. The research work also evaluated eco-tourism potential, sustainability and also its contribution to poverty reduction in the surrounding areas.

Sarma and Saikia (2008) studied on the resource utilization of the wetlands, by the rural inhabitants of the Nagaon district, Assam. The study not only deals with the resource utilization but also focuses on the socio-religious and cultural attachment with the wetlands. It revealed that fifty three plant species can be utilized for various purposes like for medicine, vegetables, fodder, bio fertilizer, etc. The fishermen of the area wholly depend on these wetlands for fish resource. Since, the wetlands proves to be rich in plant and animal resources, therefore, people often visit the wetland sites for the collection of traditional medicinal plants, fodder, raw materials for small scale industries etc. However, the maximum economic benefit is gained from fish resources. Structured questionnaires, participatory methods were used in collecting information. Thus, it can be interpreted that wetland creation or wetland restoration can be helpful in providing significant benefits to the surrounding system in addition to water quality improvement.

Knight (1993) noted that wetlands placed high in the watershed are likely to have more intermittent, less reliable water supplies, and thus exhibit lower primary production and lower overall food chain benefits than those low in the watershed with perennial water supplies. However, the aesthetic and recreational values of urban wetlands also need specific assessment and observation.

Human Impacts on Wetlands

Kiviat (2014), in his paper entitled "Adaptation of Human Cultures to Wetlands Environments" clearly mentioned that wetlands in most places of the world have caused the abundance of resources and occurrence of hazards to humans. Here resources includes food, fibre, cultivable soil, water etc.; whereas hazards include flooding, hazards to human safety and health, dense harsh vegetation, water related disease etc. The study also states that "analysis of cultural adaptations to wetlands facilitates understanding of archaeology, environmental psychology, responses to climate and hydrological change, resource management and urbanization".

Lamsal *et al*. research work on "Sustainable Livelihoods through Conservation of Wetland Resources: A Case Study from Ghodaghodi Lake, Western Nepal" (2015), investigated and studied the participation of local ethnic groups in the mode of wetland preservation; determined the economic gains of the wetlands; and even assessed the socio economic factors that can affect the dependency on wetlands. A total of 217 wetland resource-user households were surveyed, and the data collected were analyzed using descriptive statistics, t-test and ordinary least squares regression.

Roder (1994), in his book- "Human Adjustment to Kainji Reservoir in Nigeria: An Assessment of the Economic and Environmental Consequences of a Major Man-Made Lake in Africa", tries to evaluate the Nigerian development in areas such as agriculture, subsistence fishing, population, public health etc., over the past 25 years. This volume is an assessment of the consequences of the reservoir, on the local population around Lake Kainji. However, focus on the numerous social effects of resettlement and economic life of the new lake sides also discussed. A significant fact revealed through this volume is that the changes which have taken place in the Kainji lake region after the reservoir came into being, were not a part of the planned project.

Fadden *et al*. (2007 tried to develop a Wetland Change Model. This model has been developed in order to identify the vulnerability of coastal wetland at a broad spatio-temporal scale. The spatial scale ranged from regional to global, and the mean spatial resolution was of 85 km. Similarly, the temporal scale chosen was for a period of 100 years. The model provides a dynamic and assessment of wetland loss and also a means of estimating the transition between different vegetated wetland types and open water under a range of scenarios of changes in accommodation space from human intervention and sea level rise. Moreover, the paper also analyses the threshold of wetland loss and transition.

Another significant case study was put forwarded on Tianjin Palaeocoast and Wetland National Natural Reserve (TJPW), China (2012). The study reviewed its development process, evolutionary mechanisms and the status of adjustment. Secondly, aspects like, land use/ land cover change and land use policy changes, adjustment schemes and driving forces were also investigated. The land use changes were studied by supervised classification of Landsat TM remote sensing images of 1988, 1998 and 2008 respectively. The study further focused the point that boundary adjustment is needed for rationalizing the functional zones and adjustment strategy for a sustainable development of resource management.

Day *et al.* (2008) emphasized on three important dimensions of climate change effects on ecogeomorphology. These are – sea level rise, change in storm frequency and intensity and changes in freshwater, sediment and nutrient inputs. The work also focused on the human impacts on wetlands at various scales. At the global scale, humans are altering climate at a rapid rate compared to that of historical and recent geological record.

Highfield and Brody (2006) examined the impact of wetland alteration on flood damage among the local jurisdictions in Florida, over a 7 year period. The wetland loss was measured by the record of permits granted under Section 404 of the Clean Water Act. Further the result was interpreted that location of wetland permits, act as significant predictor of flood damages.

Schot (1991) basically dealt with the solute transport by groundwater flow and the way in which solute transport is affected by human activities. Hi study even incorporated the study of wetland ecosystem of the eastern part of Vecht river plain in The Netherlands, which over the past decades and has faced severe deterioration.

Burley *et al.* (2012) reviewed the concepts of adaptation, integration and synthesis in order to study the coastal wetlands in South East Queensland, Australia. The study analyzed that the pattern of distribution and conditions of coastal wetlands will gradually change as the climate changes. This change will further lead to some conservation challenges and economic cost. However, such challenges or cost can be minimized by drawing from a broad sectoral perspective in undertaking adaptation planning and also by ensuring integration into policy. Further adaptation to sea level rise focuses on wetland and biodiversity conservation, are likely to have impacts for urbanization patterns. Such planning regulations providing spatial buffering around the wetlands may give rise to compact urban forms. These compact urban forms can further lead to reductions in the cost of defense against sea level rise, reduce energy usage per person and even provide more green space.

The research work entitled "The Sustainable Coexistence of Wetlands of Rice Irrigation: A Case Study from Tanzania", by Bruce Lankford and Tom Franks (2000), aims to understand the causes for dry season zero flows in the previously perennially flowing Great Ruaha River, which drains from the Usangu wetland. The study reveals that the simple explanation of competition for water irrigation and wetlands alone is not sufficient in order to explain the reduced flows. In context to this the study suggests that complex biological and hydrological processes influence the allocation of water between irrigation and wetlands. An important hypothesis of this study is that the sustainability of rice irrigation and wetlands can be supported by recognizing its dynamic form or nature; and certain rice type irrigation development may not prove detrimental to the Usangu wetlands.

Ghermandi *et al.* (2010), carried out a research work on the "Values of Natural and Human Made Wetlands: A Meta-Analysis", which basically assimilated the values of goods and services provided by wetland ecosystems. However, main focus was accentuated to the human made wetlands. The study further found that water quality improvement, non-consumptive recreation and provision of natural habitat and biodiversity are highly valued services. Wetland values are found to be increasing with anthropogenic pressure.

1.6 Organization of the Study

The present study is organized into three parts: introduction, analysis and synthesis. The first part comprises the Chapter I and Chapter II. The first chapter is an introductory one stating the problem with specific objectives and methodologies and the second chapter is about the geographical background of the study village.

The second part includes the analysis of the present status of varied hydrological environment of the village (Chapter III), changes in rural hydrology and utility pattern (Chapter IV) and rural hydrology and livelihood issues (Chapter V).

The last part of the work, i.e. (Chapter VII) is the synthesis of the work including summary and conclusion and a few suggestions for making the hydrological environment of the village sustainable for the rural life and livelihoods.

1.7 Limitations of the Work

The present study has been carried out with the constraints of time, lack of secondary data, sophisticated machines and tools, capital, etc. Besides, as the study is related to the hydrological conditions prevailing in micro physical settings, rainfall data is not found as there is no rain gauge installed in the village and thus, this has proved to be a major constraint to carry out the present study. Again, other data on infiltration, evaporation, evapotranspiration, etc. are also not available; for which it became difficult to cover all the aspects of the study within the stipulated time. As the developmental activities have disturbed the hydrological as well ecological settings of the village, there lies immense potential to carry out further study or research. The degradation of ecohydrology, being a global concern and a major area of research therefore, needs to be investigated and put forward solutions to them.

1.8 Local Terms and Terminologies

Ahutoli – Autumn rice field

Salitolis – Winter rice fields

Bakorimati – Grazing land

Balimati – Sandy soil

Baotoli– A typical of s*ali* rice variety planted on very low land

Bihu – A traditional Assamese festival

Beel- A type of wetland

Pukhuri – Man-made pond

Khal – Natural pond

Pitoni - Marshes

Kolong – A tributary of the river Brahmaputra

Mora-Kolong – A dead channel of the river *Kolong*

Dabmati - Lowlands

Doloni - Swamps

Faringtoli - lands which are higher in elevation and do not get inundated with flood or rain water, also known as *bam-mati*

Bam-mati – lands which are higher in elevation and do not get inundated with flood or rain water

Chuburi - Hamlets

Bigha – Land measurement unit in Assam; 1 *bigha* = 0.13386 hectare

Kutcha road –Non-metallic road

Polosua mati – Alluvial soil

Satah – Continuous spell of rain for a week or more

Baak- A type of ghost that resides in water bodies

Sonpora mati – Fallow land

Mandal – A fiscal officer-in-charge of a circle

Hola – Shallow depression

Bordoichila - A local storm that blows during pre-monsoon season

Ronga mati – Red soil

Rajohua pukhuri - Public pond

Banh – Bamboo

Nodi – River

Morasuti - Dead channel

Chadar-mekhela - Traditional pair of dress

Kahar - One who makes utensils of bell-metal

Tiwa –An ethnic group in Assam

Boro rice – Summer rice

Mon – Unit for weighting cereal crops, 1 mon = 40 kilograms

CHAPTER 2
THE VILLAGE IN THE VALLEY

2.1 Locational Significance

In order to study the status, functions and changes in rural hydrological environment and also the human response to varying rural hydrological conditions in the rural landscapes of the Brahmaputra valley, a village, called Kahargaon, located on the south bank floodplain of the river Brahmaputra, has been selected for detailed investigation. The village was set up on the southern bank of the Kalong River, a tributary of the river Brahmaputra. The village is located under the jurisdiction of Raha Revenue Circle of Nagaon sub-division in Nagaon district, Assam.

Kahargaon is confined within 26° 13' 59" N and 26° 12' 14" N latitudes and 92° 27' 46" E to 92° 29' 53" E longitude (Fig. 2.1). It is a typical Assamese village located in the western part of the Nagaon district covering an area of 3.80 sq. km with a total population of 1,374 as per 2011 census. It is located 5 kilometers away from the Raha town, 28 kilometers from the district headquarter- Nagaon and approximately 92 kilometers from the State capital, Dispur. The village consists of 5 *chuburis* (Fig. 2.2) and lies to the south-west of the Raha town.

The village is surrounded by Molankata village both in the east and north-east, Bamunijan and Laufulabori villages in the south, Kachuagaon village in the south-east, Bagariguri in the entire west and Khanajan across the river Kolong in the north. The entire northern boundary is demarcated by the river Kolong and a dead channel, locally called Mora-Kolong forms the eastern boundary. The river Kolong flows through the north of the village while the river Kopili flows to its south. The village is also dotted with numerous natural and man-made wetlands.

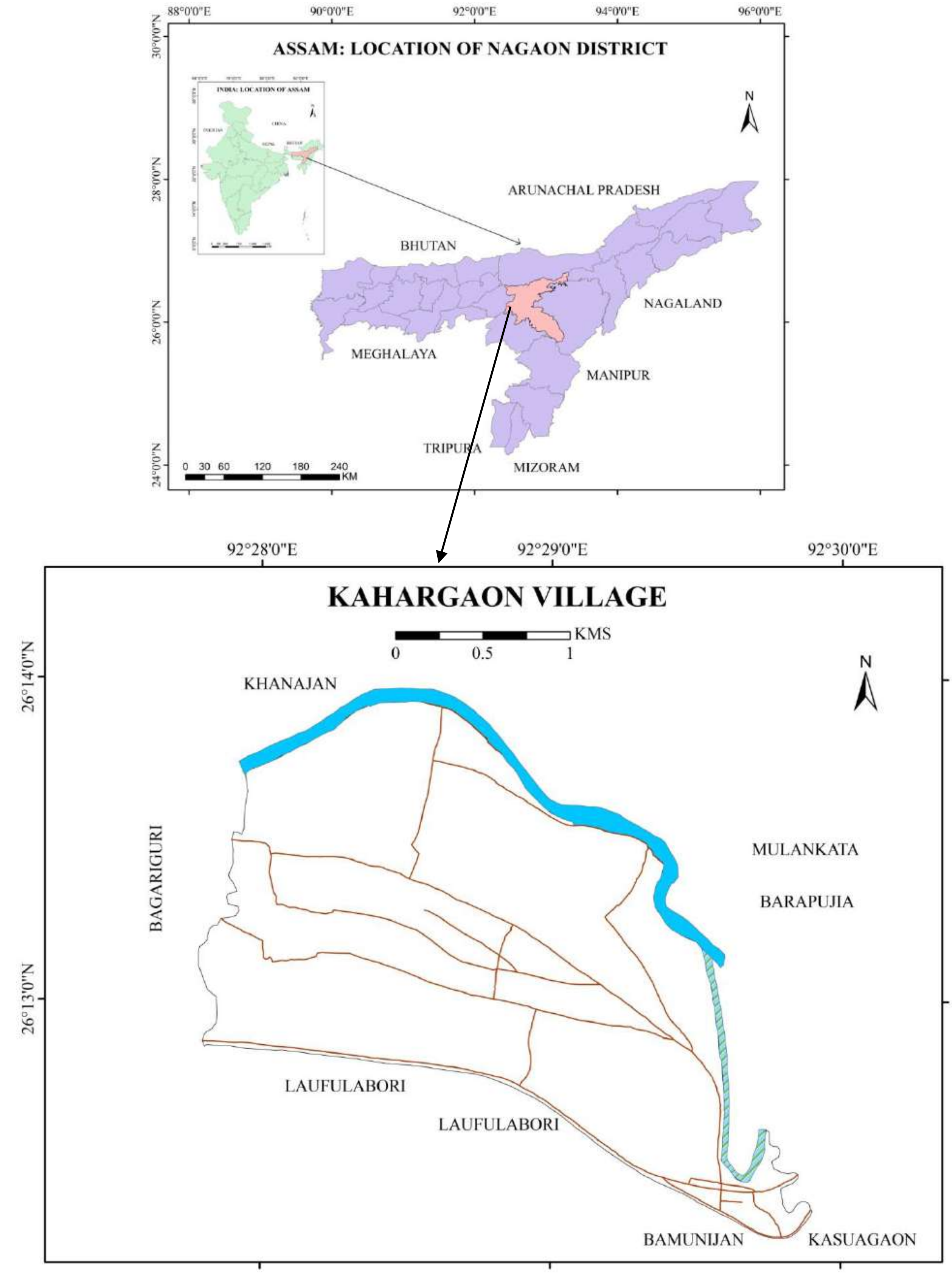


Fig. 2.1: Location of Kahargaon village

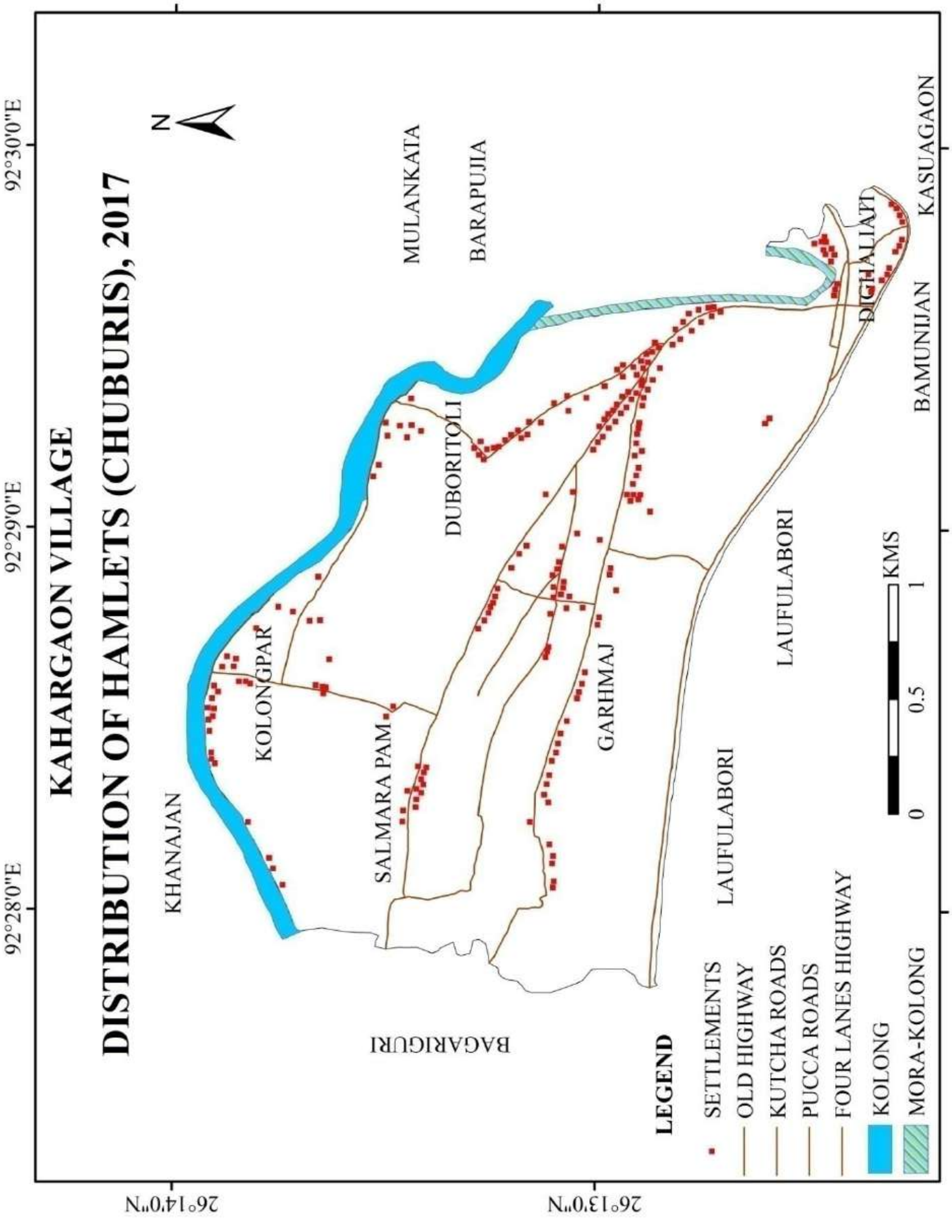


Fig. 2.2: Spatial distribution of *chuburis* (hamlets) within the village

2.2 History of the Village

The village has a significant historical background. Though no authentic written historical documents or records were found regarding the history of the village, but, based on oral interviews among some elderly people of the village, the etymological meaning of the village 'Kahargaon' has been brought into light. It is noteworthy that the name of a village reflects or shows the cultural, social and economic background of the village that prevailed in the past. The history of Kahargaon is the history of a confluence of people coming from Teok and Titabar areas of Jorhat district, Assam. It was believed that the people fled from these two places because of the Burmese invasion during 1826. At first, the people fled to the western parts of Assam and then they returned back and settled on the bank of the river Kolong in 1826. It should here be mentioned that some people moved to the nearest Molankata village during the earthquake of 1897.

The people from Titabar were originally involved in making bell-metal utensils, so they started practicing their indigenous occupation in the newly settled place. Though the people who had migrated from Teok were not originally involved in making utensils of bell-metal but after settling in the new place, they gradually involved themselves in making utensils of bell-metal. The name of the village is thus, derived from the Assamese words '*kahar'* meaning 'one who makes utensils of bell-metal' and '*gaon'* meaning 'village'. Thus, etymologically, it can be assumed that the village was earlier known as the 'village of *kahars'* and subsequently , the village got its name as 'Kahargaon'.

Earlier, the main occupation of the villagers about 70-80 years before present was making utensils of bell-metal. But with the passage of time, this occupation was no longer practiced by the people of the village and as a result of which the village is no longer exist as the '*village of the kahars*' in the recent times. The occupations or activities of the people have shifted from making utensils to other sectors of the economy. People started involving in business and services in both government and private sectors.

It is worth mentioning that as time passed; the village has become well known as Dighaliati instead of Kahargaon. Though the exact year of changing its name is not known but the new name Dighaliati was assigned to the village mainly because of the two reasons. First, as the National Highway passed through the middle of the village which is an elongated one, the village was consequently named as Dighaliati. Secondly, the village is named so after the name of the '*Dighali Beel'* located nearby. Etymologically, the name '*Dighaliati'* is a combination of two Assamese words, '*dighal'* and '*ati'*. '*Dighal'* means long or elongated and '*ati'* means road.

2.3 Physical Set up

The village being located on the bank of the river Kalong represents typical floodplain characteristics. The physiography of the village is of a flat alluvial plain with no perceptible relief variation. The village is located at an elevation of about 58.8 meters from the mean sea level (MSL). However, there are micro variations in elevation within the village and on the basis of this variation; the villagers have been designing the land surface in different patterns for various uses. The villagers classified and defined the lands as *faringtoli* or *bam-mati* (lands which are higher in elevation and do not easily get inundated with rain or flood water), *salitoli* (lands which are moderately higher in elevation) and *dab-mati* (lowlands).

The entire northern and eastern sides of the village are covered by the river Kolong and Mora-Kolong respectively. The river Kopili on the other hand flows about 3 kilometers away from the village through its southern part. Thus, the water of the river Kolong along with the river Kopili creates severe flood in the village. But the southern part of the village rarely gets inundated with flood water. It was only during the flood of 2004 that the entire village was inundated with the flood water and it severely affected the lives and livelihoods of the villagers. The river deposits alluvium frequently on the banks of the river in more or less quantity thereby retaining natural soil fertility and helping in the growth of crops and other plants. The slope of the village is very gentle (Fig. 2.4). The western part of the village has higher elevation in micro scale than the other parts but that does not affect much when the surface flow is higher.

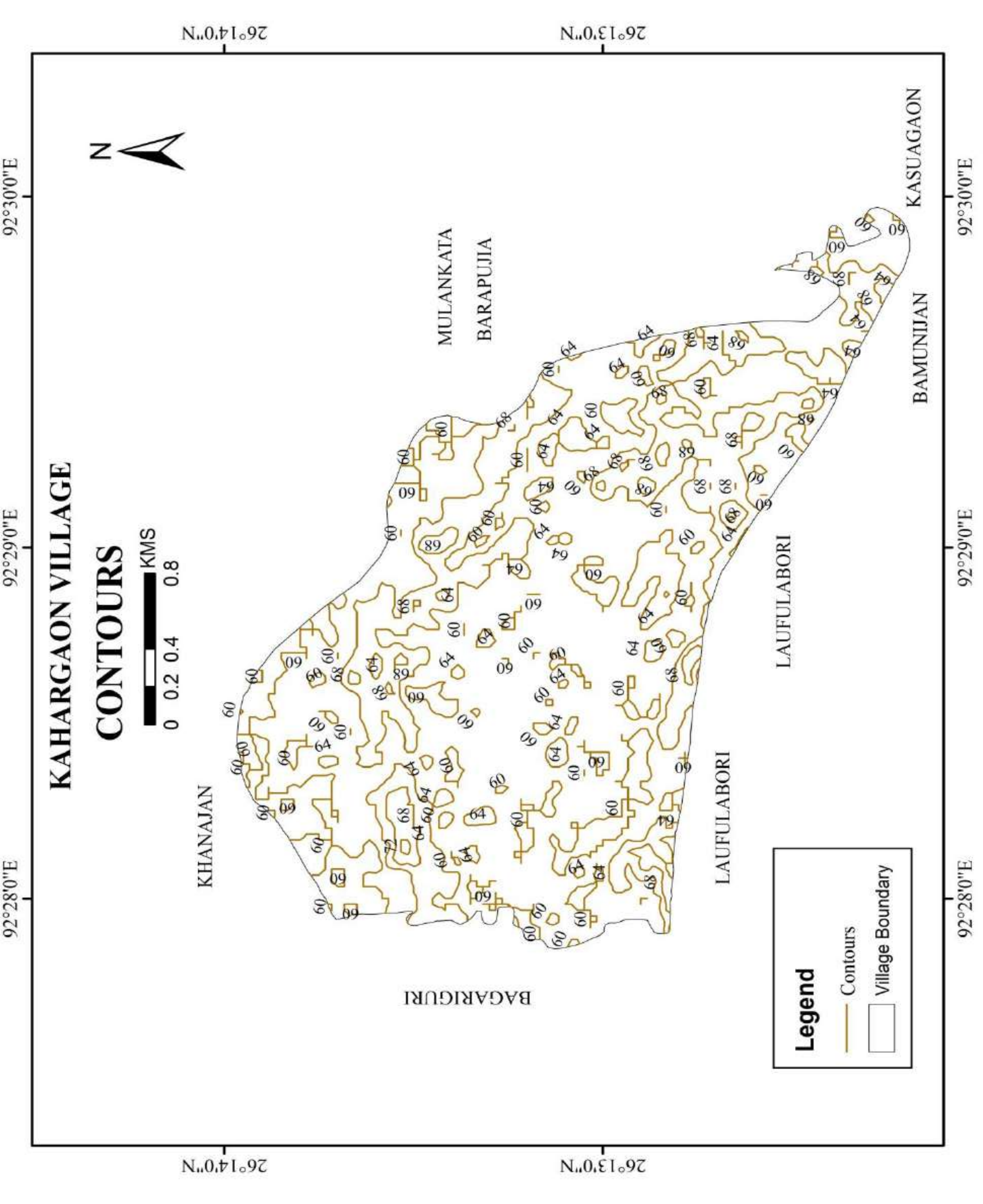


Fig. 2.3: Contour lines across the village

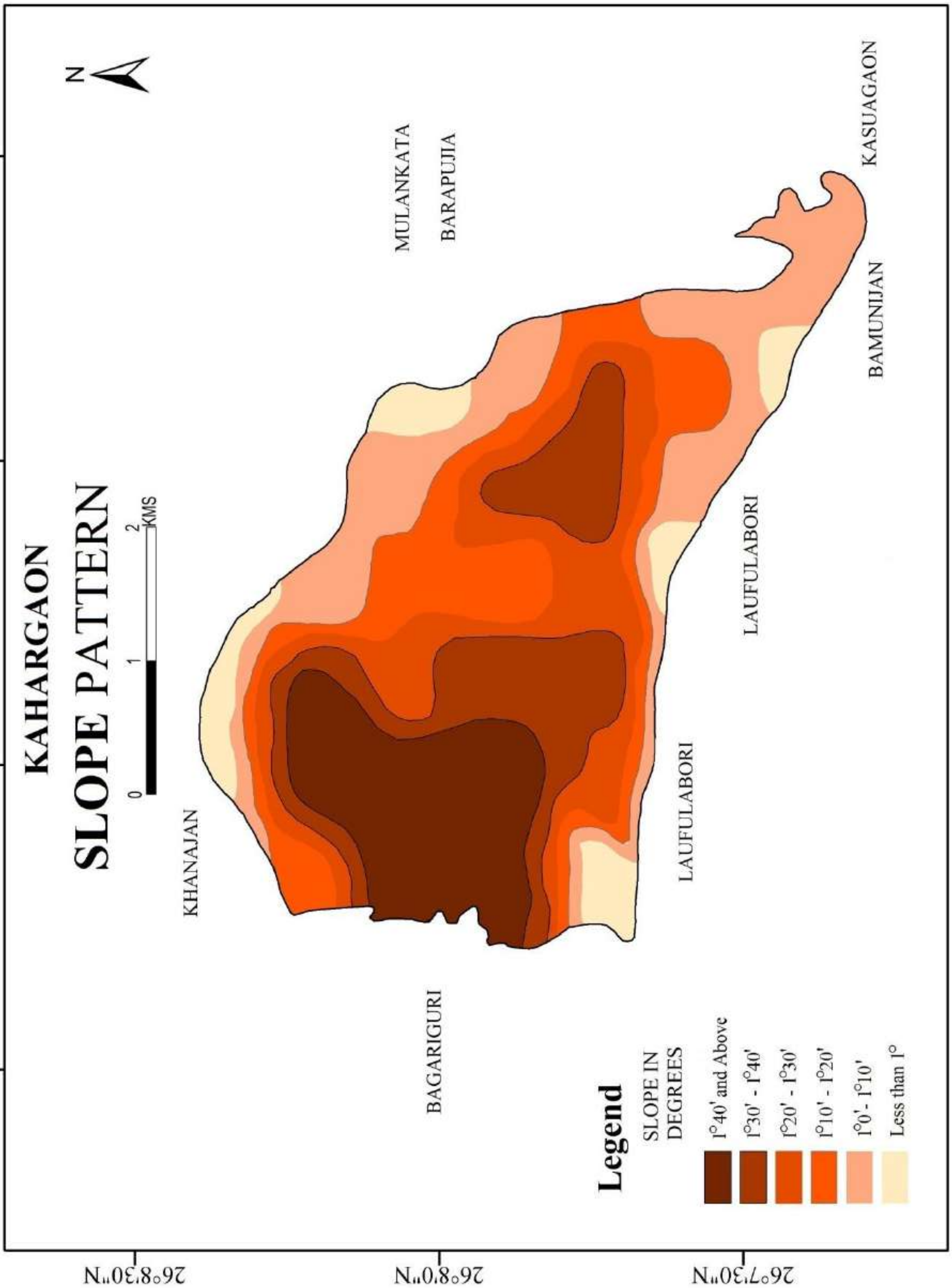


Fig. 2.4: Slope patterns in the village

2.3.1 Soils

Though the village is located on the flood plain of the river Kolong, the river at present does not deposit alluvium annually. About 40-50 years ago the river deposited annual fresh alluvium on the banks as well on the fields of its valley. But as the main river is now detached from the village and the river Kolong does not has much of potentiality to cause flood and deposit newer alluvium in its entire valley because the water discharge of the river Kolong is much lesser than before. Therefore, the major soil types of the village are *baalia mati* (sandy loamy soils), *poloxua mati* (alluvial soils), *buka mati* (clayey soils) and lateritic (Fig. 2.5).

Baalia mati or sandy loamy soils are found along the bank of the river Kolong while the rest of the village has *poloxua* or fertile alluvial soils. Alluvial soils in the village can again be divided into older alluvium and newer alluvium. Older alluvium is found on the southern part of the village where the floodwater hardly inundates the place to deposit newer alluvium while, newer alluvium is found in the northern part of the village where the floodwater of Kolong inundates that part very often. On the other hand, the south central part of the village called *Jongal Balahu Garh* and its adjoining areas have lateritic soils, which have made congenial conditions for the development of brick industry. Earlier on these fields agriculture was carried out but due to low productivity and more income generation from the brick industry, the land use was transformed apparently.

It should be mentioned here that *baalia mati* or sandy loamy soils cannot hold the water for long as its infiltration capacity is 0.9 inches per hour (Leopold, Wolman and Miller, 2015). As clayey soils contain 63% of sediments finer than 0.002 mm, its infiltration rate is 0.04 inches per hour (Leopold, Wolman and Miller, 2015). So, the water holding capacity of the sandy loamy soils containing 6% of sediments finer than 0.002 mm (Leopold, Wolman and Miller, 2015) is low compared to clayey soils. Clayey soils are mostly found in the *pitonis* and beds of the wetlands due to which water retains in them for longer period. But, as most of the soils of the village in its northern part are composed of sand, even the *pukhuris* and *khals* get dry during February-March. On the other hand, majority of the vegetation of the village including agriculture grows mainly on the alluvial soils while, the red soils also supports some vegetation.

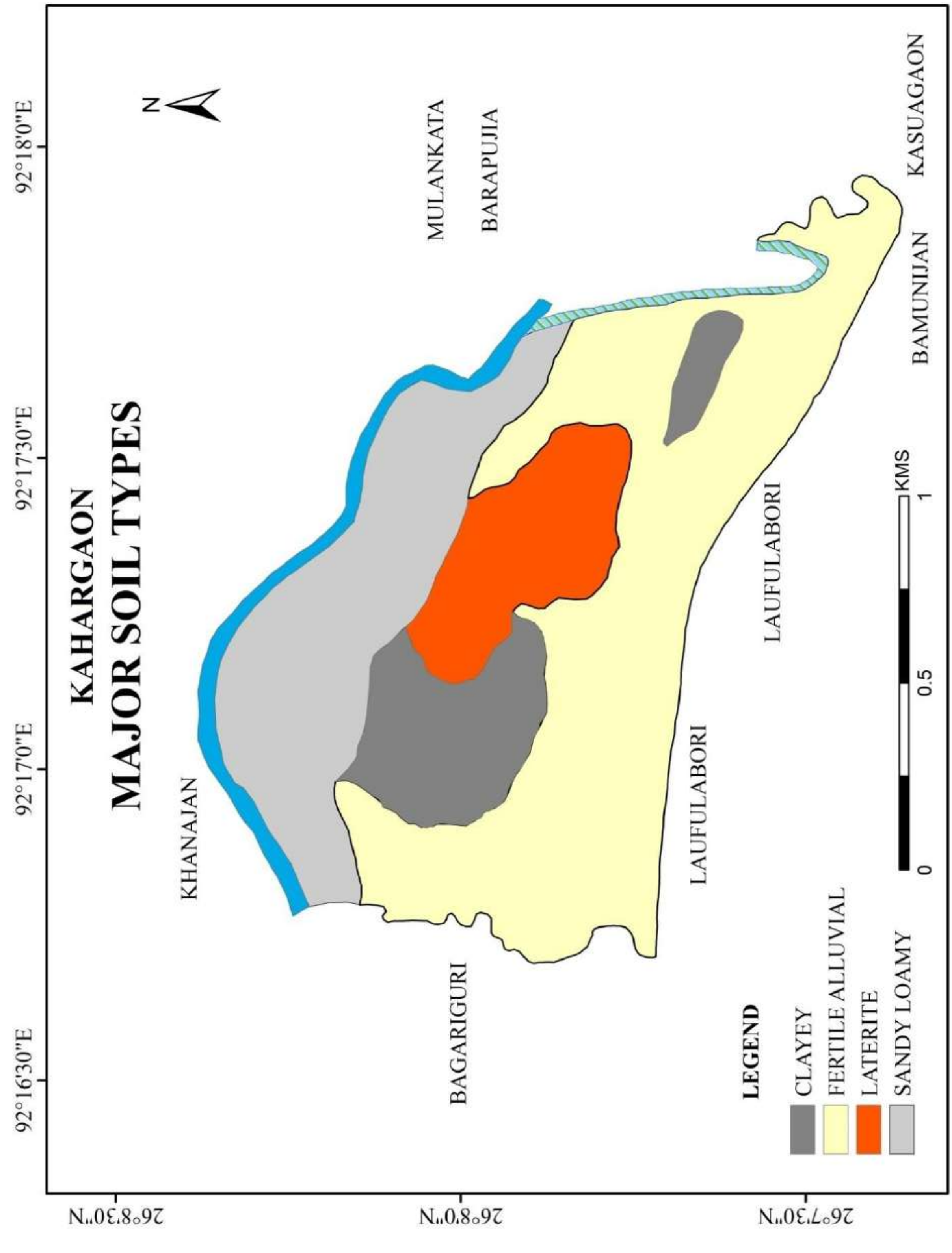


Fig. 2.5: Major soil types

2.3.2 Climate

The climate of the village is almost same with that of the climatic conditions of the middle Brahmaputra valley agro-climatic zone of Assam. The village enjoys sub-tropical monsoon climate with high humidity and heavy rainfall in summer and scanty rain in winter. Rain starts from the last week of March or first week of April and retreats before December. However, the coldest months of winter season are December and January. Temperature in winter varies from a maximum of 24.8 degree Celsius to minimum of 11.2 degree Celsius. In summer, temperature varies from a maximum of 35.9 degree Celsius to 22.5 degree Celsius, while the average maximum temperature is 30.4 degree Celsius and the minimum is 19.8 degree Celsius. The average annual rainfall is about 1850 mm.

As the other parts of the Brahmaputra valley, the village experiences four distinct seasons, which are pre-monsoon (summer), monsoon (rainy), retreating monsoon, and cold and dry winter season.

The pre-monsoon season starts from the month of March and continues upto the last week of May. During this season, temperature starts rising but rainfall is less. Dust raising squalls and afternoon showers are common in this season. Sometimes, such showers are accompanied by hail storms and are locally known as *Bardoichila* (Bhagabati, Bora and Kar, 2014).

The rainy or the monsoon season in the village starts from the month of June and continues upto mid-September. Heavy rainfall with thunderstorms, high relative humidity and light surface winds occurs during this period (Bhagabati, Bora and Kar, 2012). Almost 80% of the rainfall occurs during these months (Bhagabati, Bora and Kar, 2012). These rains sometimes cause flood.

During the retreating monsoon season, i.e. from the end of September to the early part of November, the south-western monsoon starts to withdraw from the entire Brahmaputra valley due to which the amount of rainfall gets less. During this season, the temperature also decreases and remains low considerably.

The cold and dry winter season starts from the first week of November and continues upto the last week of February. During this period, the village experiences low temperature and very scanty rainfall. Foggy morning, clear and sunny sky and cool air make the weather very comfortable (Bhattacharya, 2011; Bhagabati, Bora and Kar, 2012 and Taher and Ahmed, 2014).

2.3.3 Rivers and Wetlands

The Brahmaputra valley with its numerous tributaries and distributaries has created congenial conditions for the origin and development of various wetlands. Thus, the rural areas of the valley are dotted with a number of *pukhuris, khals, beels,* etc.

The entire northern and eastern sides of the village are covered by the river Kolong which was earlier called by the local people as *Jongal Balahu Dubi*. It should here be mentioned that, people have termed it as *Jongal Balahu Dubi* after the name of the *Jongal Balahu Garh* located in the south-central part of the village. Due to intense meandering course, the *dubi* flowed in a U-shaped pattern along the south-eastern boundary of the village. The *dubi* though not much disastrous, caused floods and affected the crops and homes of the people. The local people wanted to get relief from this effect but could not get so. In the 1970s, owing to the complaints of the local people, some government officials have dug up, joined both the edges of the meander, and let the river flow in a straight pattern abandoning the bend. As a result, the main river now flows outside the village and the part that remains abandoned is called as *Mora-Kolong*. Though the river would have naturally attained the present state after a considerably long period, it was done manually to get rid of the effects it caused to the crops, animals as well as humans. It is important to mention that the length of the river bordering the village is about 3.7 kilometers.

The village on the other hand, is also endowed with a large number of small and medium sized natural as well as man-made wetlands. They are the habitats of numerous floral and faunal species, which have their own ecological significance. They are mainly the abode of variety of species of aquatic life. Based on their size, nature of origin, aquatic characteristics and uses, the villagers have classified the wetlands as *pukhuri, khal, beel, doloni, pitoni, dubi, hola,* etc. It is important to mention that each typology of wetlands has its own unique characteristics and significance, thereby supporting different ecological settings. It has been found that there are 120 *pukhuris*, 85 *khals* and 2 *beels* the village.

However, the *pukhuris* and *khals* are spatially distributed in the village but the *pukhuris* are mainly concentrated on the southern part and those located parallel to the National Highway are fish breeding centers owned and managed by the government. There are two *dolonis* (swamps) in the village located in its Salmara Pam *chuburi* known as Kherxona and Hatigeya. However, these two *dolonis* do not possess the typical characteristics of *beels* but people locally call them as a *beels*.

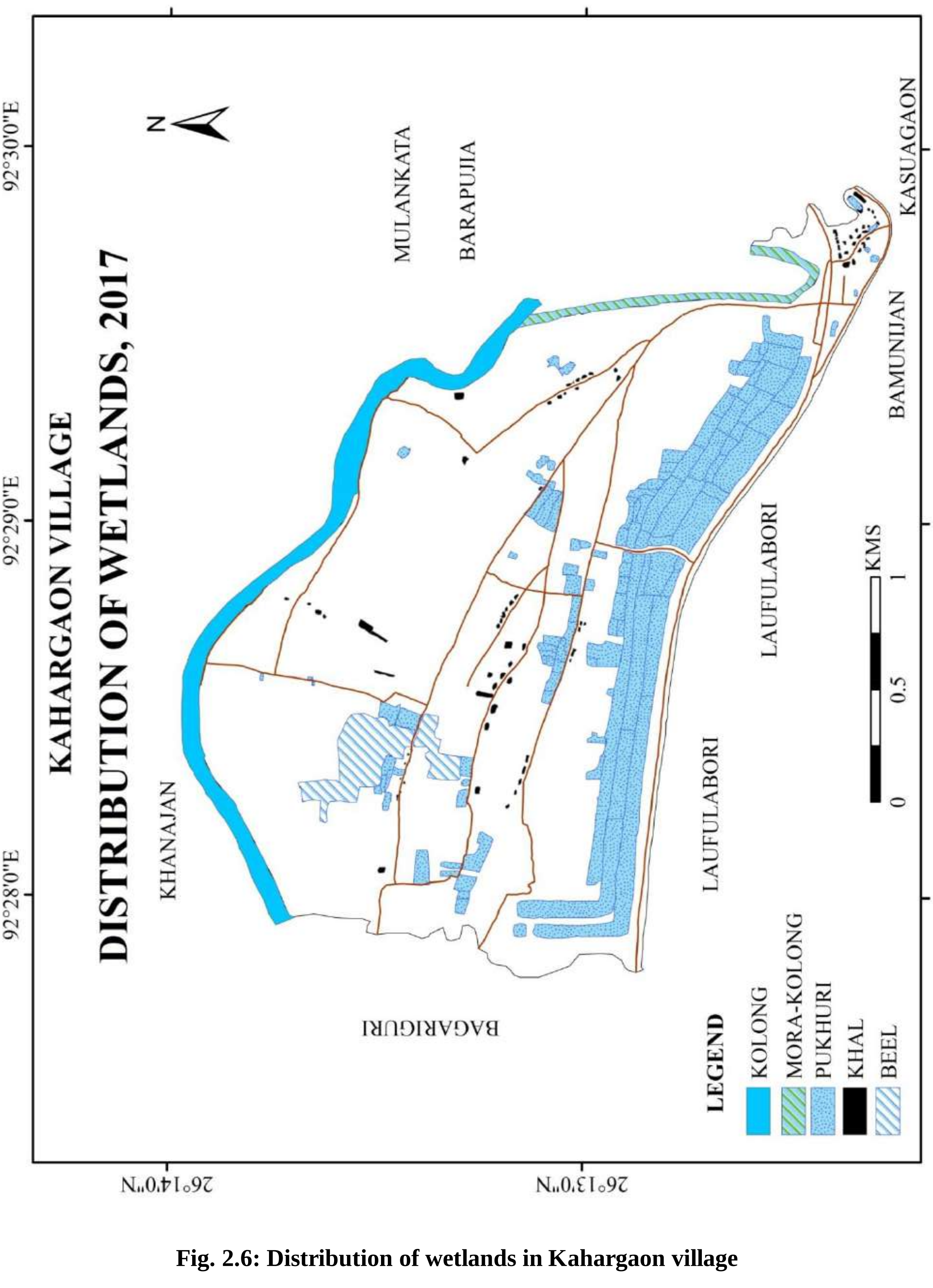


Fig. 2.6: Distribution of wetlands in Kahargaon village

2.3.4 Natural Vegetation and Wildlife

The village, being a flood plain one is fertile enough to support a variety of naturally grown plants and trees, the seeds of which are transported by the river water and deposited during floods. Apart from that, people have also planted tress once human habitation had started in the village. The sub-tropical humid climate along with the alluvial soils has made the village rich in its ecological biodiversity. There are varieties of trees which grow in the village *beel* and are useful to man in various ways (Table 2.1). The village is mainly enriched with deciduous and evergreen type of vegetation. Tall wood and fuel wood trees are quite common in the village. Besides, many grass species including bamboos and creepers have also enriched the vegetation cover of the village. It came to light that the village was earlier covered by large number of trees and grasses owing to the natural soil fertility. However, in the subsequent periods, with increasing human habitation and encroachment of forest areas for settlement and agricultural practices, the vegetation cover has decreased gradually.

The environmental conditions of the village support an abundant growth of different species of bamboos. Thus, different species of bamboos are found in the village and the main amongst them are *jati banh* and *bhuluka banh, tuku banh, makal banh,* etc. The various trees that are found in the village are mango, jackfruit, black plum, coconut, bettlenut, *azar*, great banyan, toothbrush tree, *moz, bogori*, banyan, rubber fig, wood apple and lemon. Besides, the village is also the home of many plants, some of which are used in medicinal purposes. Such plants are therefore, called medicinal plants. The plants that grow in the village include *dhekia*, *kolmou* (*Ipomoea aquatica*), spinach (*Spinacia_oleracea*), *khutoria*, *mani-muni*, *bhedailota*, *matikaduri*, *bogakosu*, *nolkosu*, lotus, water lilly, *mukua*, *ikora* (*Phragmites_karka*) and *kohua* (*Saccharum_spontaneum*).

The village with its rich and diverse vegetation has become the home of varieties of animals, birds and insects. The wild animals found in the forest patches as well as in the traditional home gardens of the village are squirrel *(kerketua)*, monkey, *hepa, guin, johamal,* rat, *neoul,* etc., snakes like *karxola, bakraj, dhuwa-saap, sakorifeti, mugafeti, kolifeti,* etc. Some of the common birds like *gharsirika, saliki, kopou, kuli, dauk, fesa, bhatou, keteki, dahikatara, kathruka, kauri, moupia, sekseki, sagun,* etc.are seen in the village.

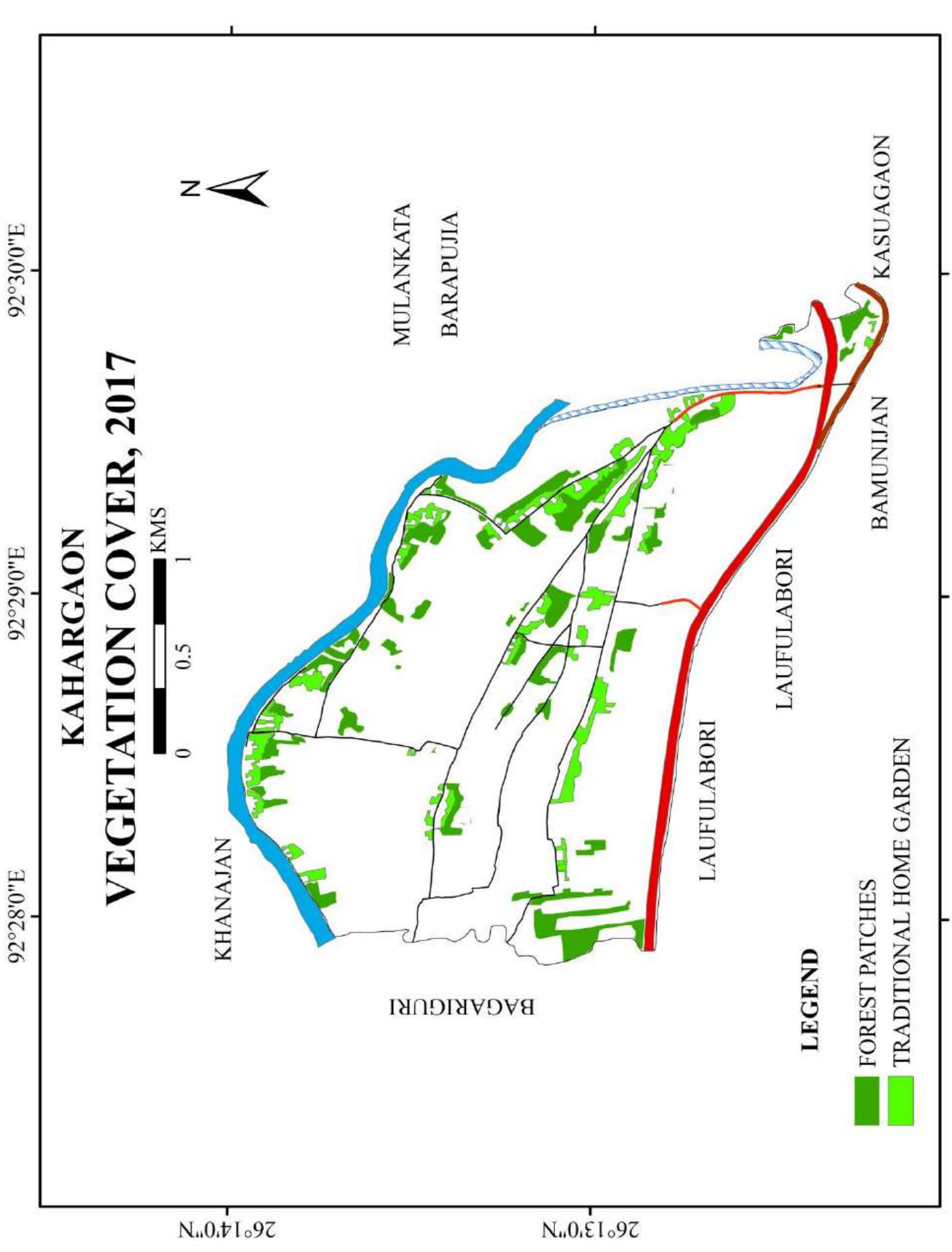


Fig. 2.7: Vegetation cover

It is worthy to mention that about 60-70 years ago, animals like tiger and python were also found in the southern part of the village alongside the *pukhuris*, especially in Garhmaj chuburi However, with the onslaught of time and increasing human intervention on the natural landscapes, many wild lives have gradually become extinct from the village.

Table 2.1: Selected floral species in Kahargaon village

Type of trees	Local name	Scientific name
Wood Trees	Sishu	*Ficus_hispida*
	Gamari	*Gemlinaarborea*
	Segun	*Tectonagrandis*
	Simalu	*Bombaxceiba*
	Kadom	*Anthocephaluscadamba*
	Poma	*Cedrelatoona*
	Moj	*Pithecellobiummonadelphum*
Fruit Trees	Aam	*Magniferaindica*
	Amlakhi	*Embilicaofficinalis*
	Kothal	*Artocarpus_sp.*
	Narikol	*Cocosnucifera*
	Kardoi	*Averrhoacarambola_L.*
	Kol	*Musa_paradisiacal*
	Tamul	*Areca_catechu*
	Bogori	*Ziziphusmauritiana*
	Teteli	*Tamarindusindica*
	Amita	*Carica_papaya*
	Madhuriam	*Psidiumguajava_L*
	Bel	*Aeglemarmelos*
	Dalim	*Punicagranatum_L*
	Leteku	*Baccaurearaniflora*
	Litchu	*Litchi_chinensis*
	Robabtenga	
Creepers	Pan	*Piper_betle*

	Bhebelilota	*Paederia_foetida*
	Kolmou	
	Bet	*Calamus_flagellum*
	Rongalau	
	Jatilau	
	Panilau	
Grass	Banh	*Bambusabalcooa*
	Kher	
Flowers	Gulap	
	Joba	
	Shewali	
	Tagar	
Medicinal Plants	Neem	*Azadirachta_indica*
	Narasinga	*Murrayakoenigii*
	Silikha	*Terminaliacattapa_L.*
	Khutoria	*Amaranthus_viridis*
	Dhekia	*Polypodium_virginianum*
	Kolmou	*Ipomoea_aquatic*
	Mani-muni	*Centella_asiatica*
	Mati kaduri	*Alternanthera_sessilis*
	Boga kosu	*Alocasia_esculenta*
	Nolkosu	
	Toothbrush tree	
Religious Tree	Great Banyan (Ahat)	*Ficusreligiosa*
	Bel	
Aquatic Plants	Kosu	*Colocasia_esculenta*
	Bhet	*Nymphaea_rubra*
	Padum	*Nelumbo_nucifera*
	Helesi	

	Dalghah	
	Mukua	*Nymphaea_lotus*

Source: Field Survey, 2017-2018

The wetlands of the village on the other hand, support a highly concentrated and diverse indigenous freshwater fish population (Table 2.2). The *pukhuris* dug up by the government of Assam in the southern part of the village lying adjacent to the National Highway are an important fish breeding and nursery ground, which supplies fish stocks for consumption for the people. Various types of fishes that are found in the wetlands are *sol*, *magur*, *goroi*, *singi*, *kandhuli*, *kawoi*, *puthi*, *borali*, *kuhi*, *mirica*, *dorikona*, *sal*, *bheseli*, *ged-gedi*, *muwa*, *dhekera*, *rohu* , *selekona*, *grasscarp*, *tura*, *kuchia*, *boti kora*, *patit mutura*, *misa maas*, *sengeli*, *chanda*, *chital*, *seniputhi* and *eleng*.

Table 2.2: Some common fishes in the wetlands

Local name	Scientific name
Sol	*Channa marulius*
Magur	*Clarius batrachus*
Goroi	*Channa punctaturs*
Singi	*Heteropnustus fossils*
Kandhuli	*Notopterus notopterus*
Kawoi	*Anabas testudinus*
Puthi	*Puntius sp*
Kholihona	*Colisa faseiatus*
Muwa	
Kuhi	*Labeo gonius*
Mirica	*Cirrhinus mrigala*
Dorikona	*Rasbora donieonius*
Sal	*Channa striatus*
Bheseli	
Barali	*Wallago attu*
Ged-Gedi	*Nandus nandus*
Dhekera	*Catla catla*
Selekona	

Rohu	*Labeo nohita*
Grasscarp	*Ctenophryngodon idella*
Tura	*Mystacemballus puncallus*
Cuchia	Monopterus cuchia
Boti kora	*Botia Dario*
Misa maas	*Palemon*
Sengeli	*Chamna gachua*
Seni Puthi	*Punetius sarana*
Chanda	*Chanda nama*
Chital	*Notopterus chitala*
Eleng	*Rasbora elenga*
Patit Mutura	

Source: Field Survey, 2017-2018

2.4 Cultural Make-up

The village has a rich cultural background. The cultures of the people in Kahargaon are reflected in their language, festivals, food and dress habits, religious rituals, marriages, house types, etc. The village is inhabited by Assamese people as the culture of the tribal Assamese people is bit different from the non-tribal Assamese people but as they have been inhabiting in the village from a very long time so, they have well-adjusted and adapted to the culture of the non-tribal Assamese people.

2.4.1 Festivals

The main festival of the village is *Bihu*. *Bihu* is the main festival of the Assamese people. *Bihu* is of three types- *Bohag Bihu* or *Rongali Bihu, Kati Bihu* or *Kongali Bihu* and *Magh Bihu* or *Bhogali Bihu.* Among them, the *Bohag Bihu* is the most widely celebrated. During *Bohag Bihu*, the domesticated animals of the village, especially the cows are taken to the nearby *rajohua pukhuris* (public ponds), Mora-Kolong and Kolong and are given their traditional ritual bath. Again during some *pujas* and other ritual activities, the flowers, leaves and other ritual items used during the ritual functions are drained mainly in the *morasuti*, Kalong and other wetlands like *pukhuris* and *khals*.

The people of the village who are living in different towns and cities of Assam for different purposes like education, jobs, etc. come during that festival to their native homes and celebrate it with their families. Different competitions ranging from drawing, extempore speech, quizzes, poem recitation to various games are held during *bohag bihu* in the open fields located at each *chuburi*. It is quite interesting to note that, in each of the competitions along with the children and other participants, women of the village also take active part in running out the events. Besides, cultural nights are also observed in which the people of the village perform various local Assamese songs and dances; and sometimes tribal dances are also performed. It is not only the Assamese people who celebrate and participate in these events; the Muslim people living in the nearby village also actively take part in these events and celebrate *bihu* too. Besides, *holi* and *diwali* are the other major festivals celebrated by the villagers.

2.4.2 Linguistic Composition

Earlier the tribal people living in the village used to speak their indigenous Tiwa language, but with the passage of time they now speak Assamese instead of their own traditional language. They have gradually well-adjusted themselves to the Assamese society as a whole. Thus, the people of the village speak Assamese and Tiwa language has been facing threats of its existence as people no longer speaks it and will definitely become extinct in the coming years.

2.4.3 Food and Dress Habits

Chadar-mekhela is the main outfit of the women of the village. While, the men of the village earlier wore *dhoti* and *kurta* but now these clothes are being replaced by pants, shirts and T-shirts. But during religious functions, men mostly wear *dhoti* and *kurta*. Earlier, these traditional dresses were made at home but after the 1980s this tradition gradually vanished with time and their home-made dresses were replaced by the ready-made western clothes available at the market. The tribal people of the village earlier wore *joskai* and *foskai* but now they wear *chadar-mekhela*. It is important to note that he fishermen usually wear *gamosa* and *dhoti* while fishing and the women while fishing wear *mekhela* tied up on their breasts.

Rice is the staple food of the people of the village. Besides, people used to collect edible plants from their home gardens, banks of different wetlands and even from the road sides that grow naturally. Thus, people had a close association with the nature and obtained food from the nature itself. But now such collection of edible plants from the nature is rarely seen rather, these plants are being bought from the nearby markets.

2.4.4 House Types

The houses of the village are mainly of Assam type. Besides, few RCC buildings are also constructed in recent years. Those people belonging to BPL, having *kutcha* houses were being replaced by *pucca* houses under the Indira Abash Yojana (IAY). Moreover, many of the houses have *pucca* walls with *kutcha* floors. Each of the households has a courtyard which is a common morphological feature of the villages.

Fig. 2.8: Different house types in the village

The altars of the houses in the village were earlier not higher and were only 0.5 feet to 1 foot high from the courtyard. But, from the later part of the 1990s, the houses have been built with comparatively higher altars. Their heights increased to as high as 2.5 feet on an average so that flood water cannot enter the houses. Interestingly, the altars of some of the houses have been built with heights above 4 feet while, the houses which were not rebuilt have the same heights of altars as before.

2.5 Demographic Characteristics

Kahargaon is a typical Assamese village inhabited by indigenous tribal and non-tribal Assamese people. The population of the village is distributed over its 5*chuburis* (hamlets). It has a total population of 1,374 with total households of 291 as per census of 2011. The village is highly populated with a population density of 362 persons per sq. kilometer. The village is inhabited by people belong to different ethnic groups, like *Kalita, Koch, Keot, Ahom, etc.* The total number of males belonging to Scheduled Tribe (ST) is 169 and that of females is 176. On the other hand, the total number of males belonging to Scheduled Caste (SC) is 36 and that of females is 25 (Primary Census Abstract, 2011).

Table 2.3: Demographic structure, 1991-2011

Years	Total no. of HH	% Growth of HH	Total population	% Growth of population	Total no. of males	% Growth of males	Total no. of females	% Growth of females
1991	163	-	916	-	472	-	444	-
2001	228	+39.87	1120	22.27	567	20.13	553	24.55
2011	291	+27.63	1374	22.68	712	25.57	662	19.71

Source: Primary Census Abstract, 1991, 2001, 2011.

The growth of population in the village is showing a positive trend because people from nearby places have migrated to the village mainly due to agricultural purposes. Again birth rate is another factor which has induced overall population growth rate of 22.68% in 2011 as compared to 22.27% in 2001 (Table 2.3).

Table 2.4: Various population parameters in Kahargaon

Parameters	Total population	Male	Female
Total Population	1,374	712	662
Children (0-6)	192	112	80
Literacy	75.72%	81.17%	70.1%
Scheduled Caste	61	36	25

Scheduled Tribe	345	169	176
Illiterate	479	225	254

Source: Primary Census Abstract, 2011

The depopulation scenario in the village has become quite a serious issue in the village where people move out mainly to avail educational facilities, employment, better livelihood business purposes. The depopulation scenario has become serious when permanent migration of people from the village to the urban centres has started. This process however, accelerated from the 1990s (Table 2.5).

Table 2.5: Depopulation scenario, 1960-2017

Years	No. of HH involved	No. of persons moved	Permanent	Temporary
1960	2	2	0	2
1970	4	5	1	3
1980	8	9	3	6
1990	8	11	5	6
2000	10	11	4	7
2010	12	14	5	9
2017	14	20	6	20
Total	**58**	**72**	**24**	**53**

Source: Field Survey, 2017-2018; Note: Married Girls are not included.

Among the *chuburis*, *Dighaliati* has the highest depopulated persons followed by *Duboritoli*, *Garhmaj*, *Kolongpar* and *Salmara Pam*.

2.6 Economic Conditions

In terms of natural resources endowment, the economy of the village is not purely agrarian. Agricultural sector in Kahargaon village provides livelihood to almost all the people of the village either in direct or indirect terms. Rice is the staple food of the inhabitants and paddy and mustard are the principal crops of the area.

There are around 1374 people in the village; most of which belong to middle class families and only a few people belong to below poverty line (BPL).

2.6.1 Agriculture

The croplands of the village are generally dominated by the cultivation of rice. Besides, the cultivation of sugarcane, mustard, jute, black gram, vegetables, etc. is also practiced in the village. It is important to note that hydrology of an area largely determines the type and pattern of agricultural practice. As different crops need different water level for their growth, the farmers with their traditional knowledge try to adjust with the varying hydrological conditions of the fields by practicing different crops.

Winter rice (*Sali dhan*) is mainly cultivated in the village and only a few number of people practice summer rice (*boro dhan*) cultivation. It should, however, be mentioned that there are only 26 farmers who cultivate crops through their own efforts. The rest of the villagers used to give their lands to farmers on different tenure systems, such as mortgaging, leasing and sharing systems. The basis of their lease is that the land is given to a particular farmer for a particular year and the farmer will have to give the owner of the land 4 Mons of rice (1 Mon =40 kilograms) per bigha of land (14,400 square feet or 1,340 square meter).

Table 2.6: Size and distribution of agricultural landholdings

Size class (in ha)	**Total land (in ha)**	**Number of households possessing lands**
0-1	34.673 (36.61)	204 (88.31)
1—2	14.72805 (15.55)	11 (4.76)
2—3	27.3774 (28.90)	11 (4.76)
3—4	9.36885 (9.89)	3 (1.3)
4—5	8.5675 (9.04)	2 (0.087)
Total	**94.7148**	**231**

Source: Field Survey, 2017-2018

Note: Fig. in the parentheses indicate the percentage to the total

The agricultural scenario in the village is not similar in all the *chuburis* (hamlets) because of the differences in soil quality in general and hydrological conditions in particular. Thus, based on their traditional or ancestral knowledge, the farmers in each *chuburi* adopts different strategies and cultivate crops those are suited to the area. At present, the village has a total agricultural land of 94.7148 hectares (ha.). The agricultural scenario in the village is dominated by rice and mustard. The land holding sizes in the village is mostly less than 1 hectare or 7.47 *bigha* consisting about 34.67% of the total land holdings (Table 2.6).

Table 2.7: Production of various crops in Kahargaon village, 2017

Crops	**Area (in ha.)**	**Production (in Quintals)**	**Remarks**
Rice	53.01298	1742.43	including all the varieties of rice- *sali, ahu and bao*
Mustard	28.71482	343.199	-
Sugarcane	5.02026	49.50	Only the production of molasses have been under consideration
Jute	11.2449	33.599	-
Black Gram	4.14314	12.379	-
Vegetables	5.15395	-	-

Source: Field Survey, 2017-2018

It has been found that in comparison to other crops, the production of rice is the highest (1742.43 quintals) in the village which is cultivated in an area of about 53.1 hectares of land while the production is lowest (12.379 quintals) in case of black gram which is cultivated in an area of about 4.15 hectares of land. On the other hand, mustard is the dominant *rabi* crop in the village.

2.6.2 Occupational Pattern

It has been found that most of the people of the village are engaged in primary activities as agriculture is their main occupation. However, some of the people are also engaged in secondary and tertiary sectors. Most of the workers are males and only a few females are engaged themselves in secondary and tertiary activities. Being a patriarchal society, generally men go out to work and earn for the family while women of the families do the household chores. Some women still work in the agricultural fields along with their husbands and along with that many families of the farmers engage themselves in animal rearing, poultry and pisciculture. Earlier, weaving was a major activity among the women of the village but now, it has declined and only 28 women of the village are still practicing it.

Table 2.8: Occupational structure in the village, 2011

Occupation	Total population	Male	Female
Main Workers	331	301	30
Cultivators	176	168	8
Agriculture Labourers	59	49	10
Household Industries	18	18	0
Other Workers	78	66	12
Marginal Workers	113	85	28
Non-Working	930	326	604

Source: Primary Census Abstract, 2011

It is quite a matter of concern that the number of farmers in the village have decreased gradually since 1991 (Table). Increasing urbanization, modernization and educational status have made them to opt for other activities; mainly secondary. Thus, the numbers of service holders and businessmen have increased since 1991. The youths of the village are reluctant towards agriculture, in fact, many of the youths of the village have moved out to the urban areas to work as salesmen, security guards, shopkeepers, etc. Thus, it has become a matter of serious concern as agricultural practices in the village have been gradually decreasing with time.

Table 2.9: Occupational shift, 1991-2017

Years	No. of farmers	No. of service holders (WV/OV)*		No. of businessmen (WV/OV)*	
		WV	OV	WV	OV
1991	71	48	9	12	2
2001	55	84	14	20	9
2011	32	116	48	43	17
2017	26	122	54	51	22

Source: Field Survey, 2017-2018; Note: *WV- Within the Village, OV-Outside the Village

2.6.3 Poultry

The people of the village are mostly non-vegetarians and prefer eating eggs and meat of birds of local variety. The production is however, less than the demand of the villagers. The conditions that prevail in the village are suitable for poultry farming, especially for hen, ducks, goats, etc. The people of the village mainly domesticate cows, ducks and goats. The *Tiwa* people, apart from the common animals, domesticate pigs and hens.

The hydrological conditions of the village, supporting large number of *pukhuris*, *khals*, river Kolong, Mora-Kolong, etc. provides congenial grounds for the poultry farming. Though practiced at a small scale, this activity has helped the local people in earning income during their financial crisis either by selling eggs of hens/ducks or the meat of them.

Fig. 2.9: Poultry

It should be mentioned that as the ducks move all the day in the *pukhuris* and *khals*, their droppings act as feeds for the fishes, which helps in their growth, and practice sustainable fish farming (Sasmal et al., 2010). Thus, pisciculture has become an integral part of poultry farming, especially of ducks. Again, cow dung and other poultry droppings are used in agricultural fields including kitchen garden, which is a natural fertilizer, healthy, and act as alternatives for costly fertilizers as well as (Schroeder 1980; Dhawan and Toor 1989).

2.6.4 Dairy

The people of the village have a long tradition of rearing some useful animals that provide milk, meat and dung for them. The important among them are cows and goats. The milk production is however low and basically meant for their domestic consumption. The milk production is apparently low due to poor genetic character of the local cows.

Fig. 2.10: Rearing of cattle

The climatic conditions, especially the rainfall pattern is distributed in such a way in the village that the cows can be grazed almost anywhere in the village. Sometimes, the cows and the goats drink the water of the wetlands. The water of the Kolong is often used for the purposes of drinking and bathing for the cows and goats of Kolongpar and North Duboritoli while the animals in Salmara Pam and Garhmaj drink water from the *pukhuris* and *khals*. On the other hand, the water of the Mora-Kolong in Southern Duboritoli is used by the animals of the area for both drinking and bathing purposes. In contrary, apart from the *pukhuris* and *khals*, water of the tube wells is also offered to the animals for drinking in Dighaliati *chuburi*.

2.6.5 Transport and Communication

The village is well connected to the rest of Assam as the four lanes National Highway passes through the southern part forming its boundary. Earlier it was two lanes National Highway-37 but with the completion of the East-West corridor project this new four lanes highway was build. The project started in 2004 and while constructing this highway the culvert that was earlier there to carry out flow of water to and from the southern-eastern part of the village has been lifted up thereby causing disturbance in the natural flow of surface run-off. On the other hand, the old highway which was the National Highway till 1982 forms the boundary of the village in its south-eastern corner separating it from Laufulabori and Kasuagaon.

The road from Dighaliati *chuburi* connects Duboritoli which goes to Kolongpar while two roads from Duboritoli are also diverted which goes to Salmara Pam and Garhmaj. These roads have disturbed the natural surface flows leading to fragmentation of ecological habitats.

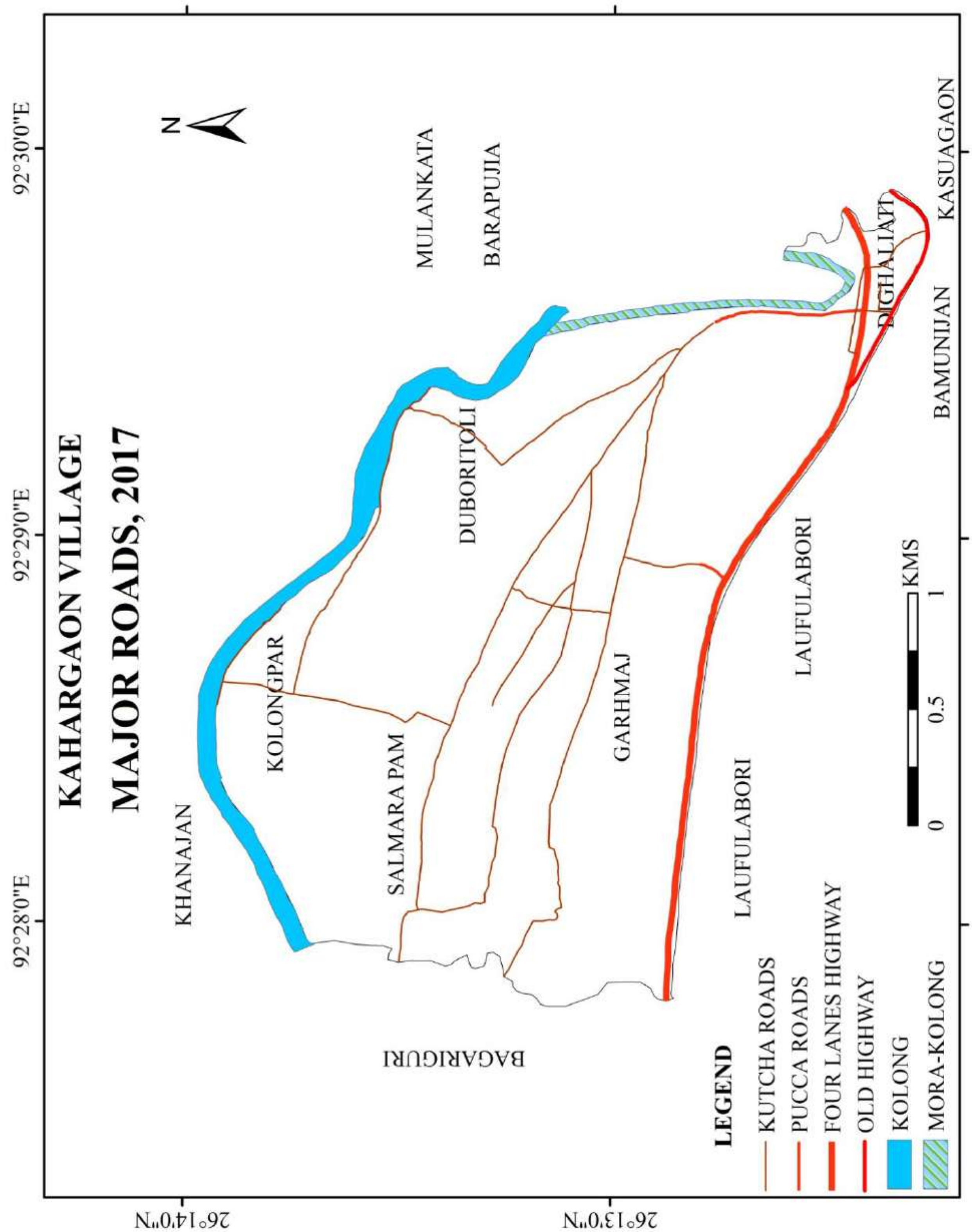


Fig. 2.11: Major roads in the village, 2017

Fig. 2.12: Different types of roads in the village

Chapter III

STATUS OF RURAL HYDROLOGICAL ENVIRONMENT IN THE VILLAGE

3.1 Present Status of Hydrological Environment

The present status of rural hydrological environment of the village can be better understood by the status of the surface water as well as underground water conditions. The status of the surface water can be assessed by the hydrological conditions of the wetlands and water concentrations on the fields in the village. The wetlands of the village have been facing some serious problems caused basically by the irrational anthropogenic activities. The wetlands of the village have been locally classified and identified as *nodi* (river), *pukhuri* (man-made ponds), *khal* (*natural ponds), beel, morasuti* (dead channel)*, hola (shallow depression), pitoni (marshes)* and *doloni.*

The river Kolong flows through the eastern and the northern part of the village. The main reach of the river Kolong flows through the northern part of the village forming its northern boundary, and a part of the river also flows through the eastern part of the village which is no longer perennial now. This part of the river is locally called as Mora-Kolong. This Mora-Kolong was made artificially abandoned from the trunk channel- Kolong. The flow of the *morasuti* (dead channel) is almost stagnant because a road has been constructed on it with a very narrow culvert. This culvert has caused habitat fragmentation and created lot of disturbances in the natural flow of the channel. Such kind of unwise human intervention has disturbed the natural wetland ecology in general and the ecology of the *morasuti* in particular. The *morasuti* becomes the congenial habitat for endemic aquatic plants and animals. The ecology of both these two wetlands, i.e. Kolong and Mora-Kolong is quite different and significant from the other wetlands. However, the numbers of fishes and other aquatic animals have been gradually disappearing from these wetlands due to many irrational human activities and anthropogenic pressure. Many of the species of aquatic animals have become endangered and many of them are going extinct. The *morasuti* is the most affected one as it has been excessively used and severely degraded by the humans.

It is noteworthy that, the number of *pukhuris* has been gradually increasing in the village with the establishment of new home usually after family separation while opposite is in case of *khals*. This is mainly because of the fact that people have dumped wastes in the *khals*, and most importantly, the newly constructed four-lane highway has buried many *khals* of the village. The *khals* are the home to a large variety of aquatic species, which are now very rarely found in the village's aquatic ecosystems. Many of the local variety of fishes are domesticated in the *pukhuris.* A common amphibian, locally called *gnui* eats up the newly born fishes and thus forms an integral part of the pond ecosystem**.**

The *salitolis* (winter rice fields) and the *baotolis also* act as seasonal wetlands, which remain covered with rainwater for almost 4 to 5 summer months of the year. In those few months, these rice fields become the habitat of many fish species, toads, snakes, insects, and even tortoises. During these months, many birds also come from distant places to feed on those insects, fishes, snakes, etc.

It should be mentioned here that, the *morasuti* flows northwards to join the Kolong river which flows from east to west of the village. However, the present status of the water flow within the village has been facing many problems as many culverts have been removed or lifted up while constructing the four-lane highway in the last decade. This has caused many serious problems as water from the south-eastern corner of the village cannot flow freely following the existing natural slope towards the *morasuti*. The slope of the village is however, very gentle. The slope gently declines from the south to the north and from the middle part of the village, the slope declines towards east and north-east. There are micro-level variations in elevations of the village topography, and because of this, the surface water flows according to the slope of the surface and ultimately fall mainly into the Kolong, Mora-Kolong and to the other natural wetlands.

3.2 Rural Hydrological System

The village experiences a unique hydrological system having distinct input and output mechanism. It is found that the monsoon rainfall and the surface runoff from the adjacent villages are the main inputs of water to the village. The surface water flows according to the micro variations in slope and finally drains as output into the river Kolong and Mora-Kolong. It is noteworthy that the River Kolong during the peak monsoon months overflows its banks and thus recharges the agricultural lands and wetlands of the village with water, fertile alluvium and other aquatic resources. Some of the aquatic faunal species, which are available in the agricultural fields during summer months, go back to the neighboring Kolong river and also to the adjacent wetlands as soon as the flood water starts receding during the retreating monsoon periods.

The rainwater in the village flows down following the micro variations in slope and thus falls onto the depressions like Kolong, Mora-Kolong, *pukhuri, khal, beel, pitoni, doloni*, etc. However, some portion of the rainfall flows into the agricultural fields of Bagariguri village through the north-eastern corner of the village (Fig 3.1).

It is worth mentioning that the surface runoff from the neighbouring Bagariguri village entered onto the agricultural fields, low-lying areas and to the wetlands of Kahargaon village, which helped in maintaining well-balanced aquatic ecosystems in the village. The water from Bagariguri village flows over the village through its north-western corner. During floods, the water of Kolong River first enters into Borxola *beel* of Bagariguri village, then the water moves into the Kherxona *beel* and Hatigeya *beel* located in Salmara Pam and thus the floodwater ultimately enters the village. Apart from this flow direction, the water of Kolong flows into the village through the pre-existing depressions. It is also interesting to note that the villagers call the low-lying fields of the village as *beels* as because these fields are remaining submerged under water for almost six to seven (6-7) months of the year which can typically be called as 'seasonal wetlands'. These *beels* can also be referred to as *dolonis*. However, after the construction of the Salmara Pam road in 1989, the water of Kolong cannot enter the Salmara Pam *chuburi* except during the high stage-discharge of the river.

Again, with the input of rainwater in the village, some proportion of the rainwater, after infiltration, evaporation and evapotranspiration get concentrated in the low-lying areas. Apart from draining out to the Kolong, its output also takes place through evaporation, mainly from the wetlands and low laying agricultural fields. It has been found after an experiment in the year 2017 that the water level of the shadow-prone ponds, whose average depth was 5.5 feet in the month of July, submerges to 4.5 feet on an average in December. While the water level of sunlight-prone ponds goes down from 5.5 feet in the month of July to 3.9 feet in December.

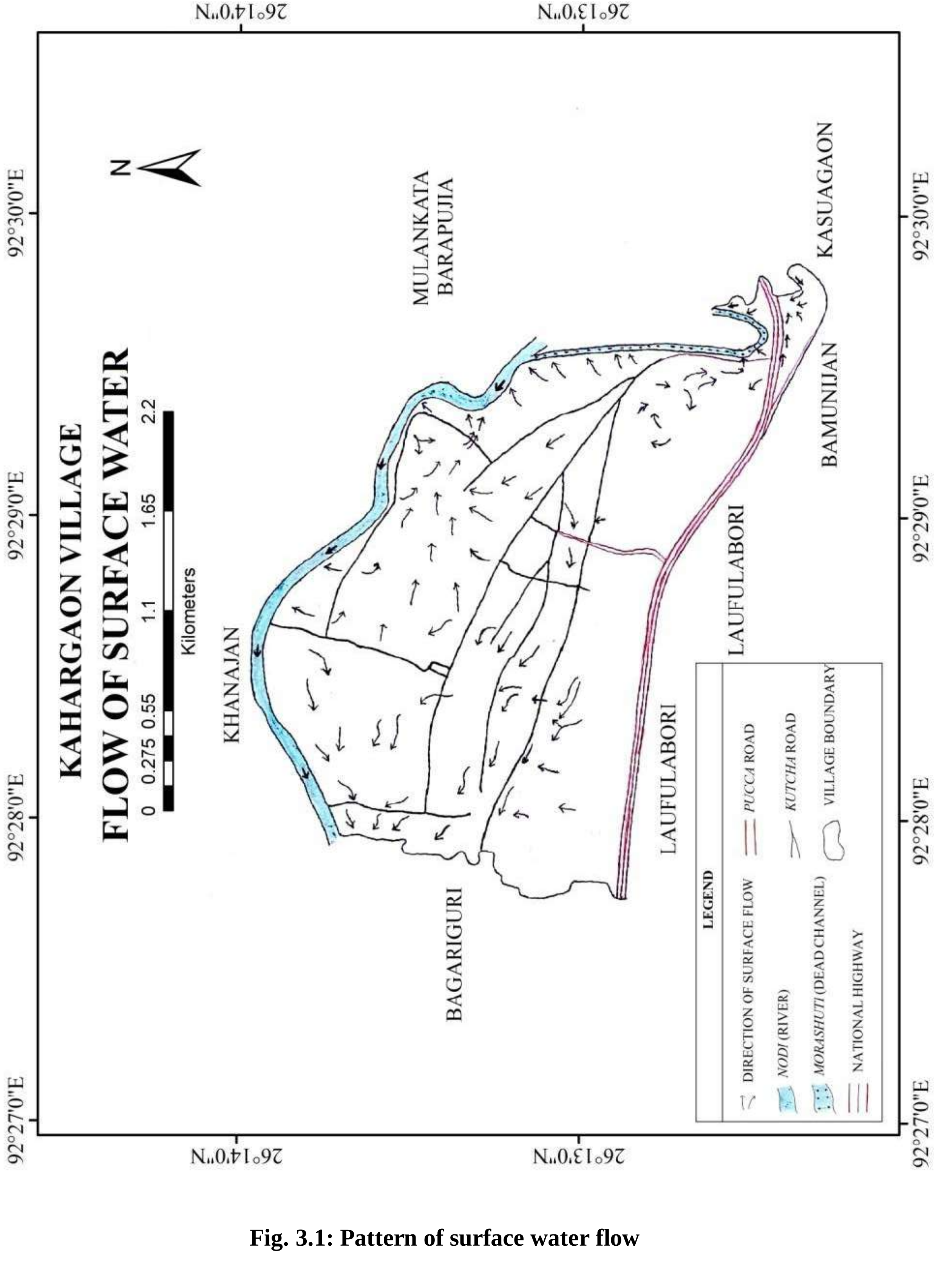


Fig. 3.1: Pattern of surface water flow

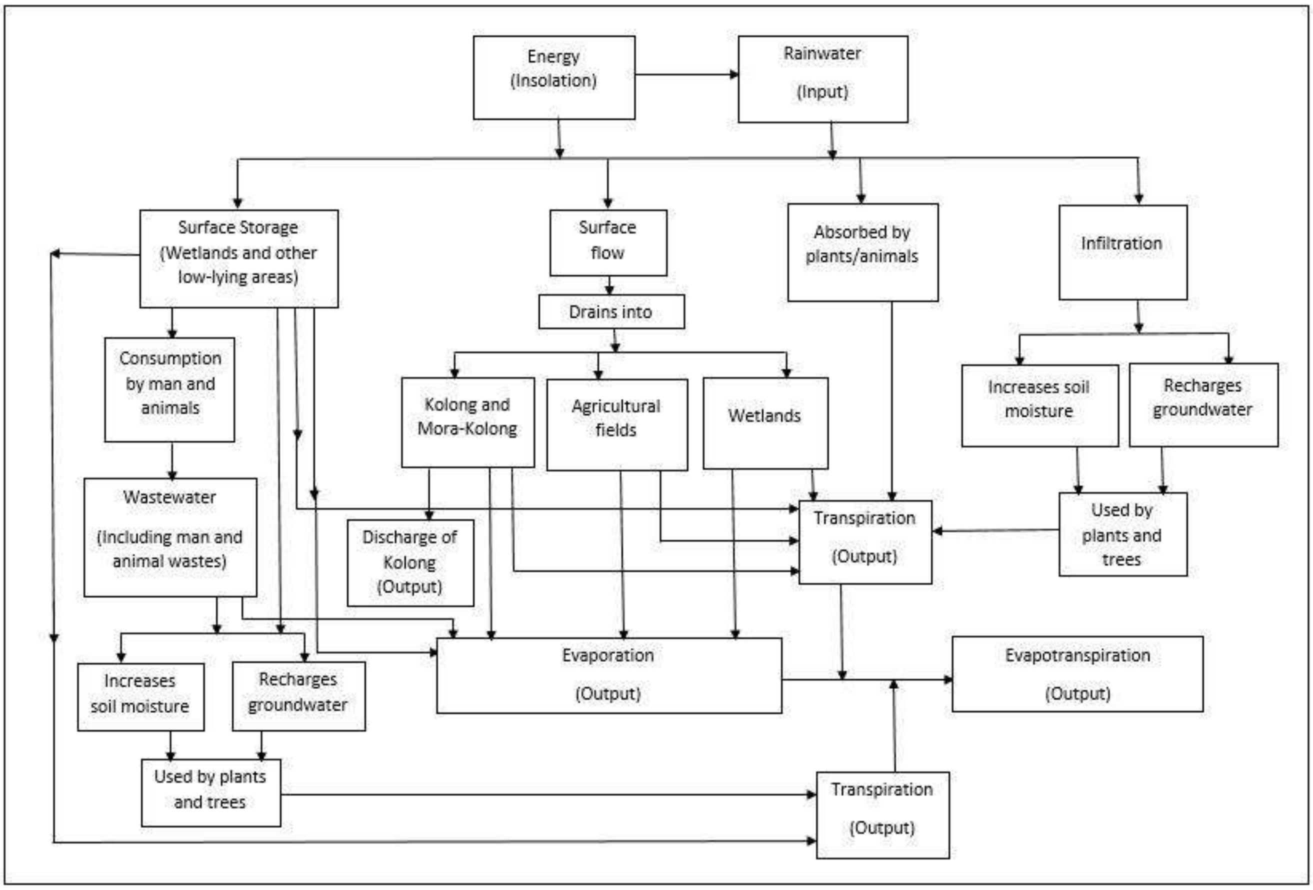


Fig. 3.2: Mechanism of inputs and outputs of water within the village

3.3 Evolution of Wetlands

It is really difficult to say about the exact evolution of the natural wetlands. The village is endowed with a number of natural as well as man-made wetlands which become an important component of rural hydrological environment. These wetlands help in proper functioning of hydrology in the village.

As mentioned earlier, the village is a flat alluvial plain with no perceptible relief variation. However, the micro variations in elevations within the village have helped in the formation of some wetlands of different shapes and sizes. The major natural wetlands of the village include the river Kolong and Mora-Kolong along with some of the *khals.* The low-lying fields, which are used for agriculture also, perform as wetlands as they remain inundated with water for almost 6-7 months of the year, which eventually becomes the home of many aquatic plants, animals and insects. In the eastern part of the village, the low-lying areas near the Kolong are one such example. Again, some parts of the low-lying areas are seen in the southern side of the village alongside the government *pukhuris*. The low-lying areas are locally called as *da-mati*.

The evolutions of the man-made ponds are quite easy to trace compared to the natural wetlands. It is noteworthy that the number of man-made wetlands is more in the village than the natural ones. In rural areas of the Brahmaputra valley, the man-made ponds are dug up mainly during the constructing houses. For example, if a plot of land is taken or chosen for constructing a house, then, people will first pile up the foundation of the house higher than the existing topography so that floodwater does not sneak inside. In order to make the alter of the house higher than the local flood level, people dug out lands from the backyard and dump it on the proposed site where the altar of the house will be built. This is the main reason behind the creation of *pukhuris* in the village. Besides, there are many *pukhuris* dugged by the government, which are used as fish breeding centers. People also dug public ponds (rajohua pukhuri) in earlier times to use them as important sources of drinking water for the rural communities. At present with the introduction of tube wells and ring wells the *rajohua pukhuris* have been used for rearing fishes for commercial purpose so that the income generated from such ponds can be invested for some community development activities and also for holding public functions, like *Bihu* function, *Sankar Utsav, etc.*

3.4 Field Hydrology

The rainwater on the rice fields, located at relatively higher elevation, naturally flows downward to the low-lying fields according to the slopes, and thus, the level of underground water gets deeper and the soils are drier in the upper fields than the low-lying fields (Boling *et al.*, 2008). Thus, the low-lying paddy fields on which water retain for longer duration helps in recharging ground water (Mizutani, 2002). In fact, the dykes (*aali*) of the paddy fields store the rainwater, which help in the growth of the crops, ultimately end up creating temporary or seasonal wetlands. The dykes on the fields (13-20 cm) help in regulating the flow of surface run-off (Chieng, 2003) and thus, run-off flows downslope through the cuts in those dykes.

The micro-variations in surface elevation, soil composition and the human intervention on the natural landscapes are the main factors responsible for the variation of surface flow, water holding capacity of agricultural lands, and the occurrence of different types of wetlands within the village. Some parts of the village are covered by water in the form of river (*nodi)*, man-made ponds *(pukhuri*), *khal* (*natural ponds)*, *beel*, *morasuti* (dead channel), *hola* (shallow depression), *pitoni* (marsh) and *doloni* (swamp). These wetlands have enriched the aquatic ecosystems within the village and provided a range of goods and services to the rural people . Again, on the basis of the level of surface water, the villagers have been utilizing the land for various purposes. The villagers have typified the lands as *faringtoli* or *bam-mati* (high lands which are not easily inundated with rain or flood water), *salitoli* (winter rice fields which are moderately low in elevation), *da-mati* (very lowlands) and *bakarimati* (grazing land).

The people first settled adjacent to the river Kolong due to availability of water and aquatic resources. However, over time because of irrational human intervention in the river flood intensity has been increasing. Therefore, people started settling on the areas having higher elevation. The flood in 2004 broke the records of all the previous floods of the village where the water level raised almost up to 55 meters from the mean sea level. This flood had the highest water level until date. Again, the due to the variations in elevations of the fields, the villagers have designed various field patterns, like *faringtoli* or *bam-mati, ahutoli, salitoli, dab-mati* etc. The water level is different in all these fields. The water level on the *foringtolis* is almost 1-1.5 ft. Therefore, the people use such fields for making settlements. The water level of *salitolis* is about 0.5-1 ft. and remains for almost 5-6 months of the year. Again, the water level of the *dab-matis* is about 3-3.5 ft.

It is interesting to note that there are some fields in the village where water cannot retain for a longer period because of their higher elevation in comparison to the adjacent winter rice fields. These fields are known as *ahutolis* (autumn rice fields) where the farmers used to cultivate local autumn rice varieties. The average water level on the *ahutolis* in the month of June is 0.225 feet which gets its highest level in the month of July, i.e. around 1 foot.

Table 3.1: Water level (WL) on autumn rice fields, 2017-18

Months	Average water level (in feet)				
	in the 1st week	in the 2nd week	in the 3rd week	in the 4th week	in the month
May	0.125	0.2	0.2	0.375	0.225
June	0.4	0.675	0.6	0.8	0.62
July	1.0	1.375	1.4	1.3	1.27
August	1.125	0.9	0.7	0.5	0.81
September	0.35	0.3	0.3	0.35	0.325
October	0.4	0.4	0.3	0.2	0.325
November	0.25	0.1	0	0	0.175

Source: Field Study, 2017-2018

On the other hand, there are some fields where water remains in the fields only from the month of May to November. So, people usually cultivate local *Sali* rice varieties on those fields where water level is relatively higher than the *ahutolis*. These types of fields are known *salitolis* or winter rice fields and the type of rice that is grown on such fields is known as *sali dhan* or winter rice. The average water level of the *salitolis* (winter rice fields) remains at 0.29 feet in the month of May which gets its highest water level in the month of July i.e. 1.97 feet. Since July, the water level goes down and in the last week of November the lands almost dries up and till then the harvesting period arrives.

Table 3.2.: Water level (WL) on winter rice fields, 2017-18

Months	Average water level (in feet)				
	in the 1st week	in the 2nd week	in the 3rd week	in the 4th week	in the month
May	0.2	0.25	0.3	0.4	0.29
June	0.5	0.75	1.0	1.5	0.94
July	1.5	2.4	2.2	1.75	1.97
August	1.70	1.4	1.30	1.10	1.40
September	0.80	0.7	0.4	0.4	0.60

October	0.4	0.7	0.55	0.3	0.49
November	0.125	0.1	0	0	0.06

Source: Field Study, 2017-2018

3.5 Wetland Hydrology

The wetlands are complex and biologically most productive ecosystems of the concerned area (Whittaker and Likens, 1973; Ghermandi *et al.*, 2008; Cherry, 2012; Bassi *et al.*, 2014) which provide a unique habitat for diverse species of plants and animals (Prasad *et al.*, 2002; Bassi *et al.*, 2014) and control the hydrological environment by reducing flood and recharging and discharging aquifers. Wetlands are one of the crucial components of the hydrological system which play a vital role in regulating the hydrological cycle (Bullock and Acreman, 2003; GWRC, 2005; Edwards *et al.*, 2015). Wetlands can perform important role in reducing peak flow and in increasing low flow runoff into streams through their functions of storing water during storm events on the one hand and releasing water during the dry season on the other (Brydon, *et al.*, 2006).

There has been no scientific attempt made so far by the hydrologists and geographers to classify the wetlands in different types distributed in the micro-environmental settings that characterize the flood plains of Assam (Deka and Bhagabati, 2015). The life and livelihoods of the rural people are intimately related to the wetlands as the wetlands provide to them a range of goods and services. However, the people of Kahargaon village, with their traditional knowledge and experience, have classified the wetlands into eight types: 1) *nodi* (river), 2) *pukhuri* (man-made ponds), 3) *khal* (natural ponds) 4) *beel* 5) *morasuti* (dead channel), 6) *hola* (shallow depression), 7) *pitoni* (marsh) and 8) *doloni* (swamp).

1) ***Nodi* (River):** The River Kolong flows through the northern and eastern sides of the village creating suitable ecological niche for a range of aquatic lives. Earlier the river was used by the villagers for drinking of water, bathing and washing, soaking of crop seeds, some building materials and jutes, drinking of water for domestic animals, fishing and many more. Still this river is the main fishing ground for the villagers. During the peak monsoon months i.e. June and July, the water reaches the bank full stage. The water level of the river in those months goes up to 49 ft. and it subsides gradually as winter approaches. During November-

December, the water level goes down to 18-20 ft. on an average while during February-March, the water level of the river further recedes to as low as 3 ft.


Fig. 3.3: Kolong reach along the village

2) ***Pukhuri* (Man-Made Ponds):** The village has a large number of *pukhuris* which act as an important hub of various fishes and other aquatic species. *Pukhuris* are dug by the villagers basically for fish rearing, bathing, washing and also to use the soil for raising the ground of their houses. It is interesting to note that the Kolongpar *chuburi* along with Salmara Pam and the northern parts of Garhmaj chuburi cannot concentrate water for long as these areas are adjacent to Kolong River and composed of sandy soils. As soon as the level of water in the Kolong goes down during winter, the water from the surrounding low-lying areas of the *chuburi* flows into the river with internal or underground linkage.


Fig. 3.4: *Pukhuris* (Man-made ponds)

Again during the months of June-July, the water of the *pukhuris* reaches the bank full stage. Thus, the volume of water is more in the *pukhuris* having greater depth. If the depth is less, the *pukhuris* will almost dry up, especially during the extreme dry season (February and March). Thus, it can be concluded that the water level of the *pukhuris* in the village depends entirely on their depths (Table 3.3).

Table 3.3: Water level of *pukhuris* (ponds) in each *chuburi*

Name of *chuburi*	Total No. of *pukhuris*	Months	Depth of *pukhuris* (in ft.)	No. of *pukhuris*	Average water level (in ft.)
Kolongpar	3	June-July	5-10	0	-
			10-15	2	11.5
			15 and Above	1	15.0
		February-March	0-5	3	2.5
			5-10	0	-
			10 and Above	0	-
Duboritoli	25	June-July	5-10	12	5.8
			10-15	8	10.3
			15 and Above	5	21.0
		February-March	0-8	17	2.5
			8-16	7	12.5
			16 and Above	1	20.0
Salmara Pam	8	June-July	5-10	1	0.00
			10-15	6	10.0
			15 and Above	1	11.0
		February-March	0-5	7	3.5
			5-10	1	5.5
			10 and Above	0	-
Garhmaj	66	June-July	5-10	32	6.3
			10-15	25	10.0
			15 and Above	9	16.0
		February-March	0-5	52	2.05
			5-10	9	5.4

			10 and Above	5	10.0
Dighaliati	18	June-July	0-5	4	4.0
			5-10	11	7.14
			10 and Above	3	10.33
		February-March	0-5	15	3.0
			5-10	3	5.0
			10 and Above	0	-

Source: Field Survey, 2017

It becomes difficult for the aquatic lives to survive in those wetlands where the water level goes down to 4 feet. The aquatic lives, mainly fishes need an optimum water level of more than 4 feet to move freely and to maintain the aquatic ecosystem. Many fishes die because of low water level and muddy water. So, people start fishing unwillingly as soon as the water starts going down.

3) ***Khal* (Natural Ponds):** These are naturally occurred wetlands caused basically by the rivers. These *khals* are ecologically very rich in comparison to the man-made ponds. The *khals* are usually not very large and they contain many wild fish species, frogs, insects, toads, snakes and much aquatic vegetation. However, the number of *khals* in the village has been decreasing as many of them are converted into *pukhuris* by digging with backhoe diggers. It is noteworthy here that the Madhucon company, associated with the construction of four-lane highway, provided the villagers of Rs.5000-6000 per *bigha* for taking their lands for road construction and also helped them in digging their *khals at* free of cost.

Fig. 3.5: *Khals* (Natural ponds)

The average water level of the *khals* of Kolongpar and Salmara Pam *chuburis* during the months of June and July attains 6 feet and 5 feet respectively, while during February and March, the water internally flows into the Kolong and eventually no water is left in these wetlands. In Garhmaj, Duboritoli, and Dighaliati, the water level remains at 5.5 ft., 4 ft. and 3.5 ft. respectively during June and July while during the months of February and March all the *khals* get dried up.

Table 3.4: Size and distribution of *pukhuris* in Kolongpar

Size class (in acres)	Total land (in ha)	Number of households possessing *pukhuris*
> 0.1	0.14	2
0.1 - 0.2	0.134	1
0.2 - 0.3	0	0
0.3 - 0.4	0	0
0.4 - 0.5	0	0
0.5 - 0.6	0	0
< 0.6	0	0
Total	**0.274**	**3**

Source: Field Survey, 2017-2018

It is interesting to note that there are only 3 *pukhuris* in Kolongpar, and the size of each of them is less than 0.2 hectare. Although the depth of the *pukhuris is* higher than the *khals* but water does not retain in them all throughout the year as a result of which the villagers cannot practice fishing. Therefore, people usually do not take much care about their sizes and many of such ponds are used as dumping ground as a result of which their sizes have started shrinking. It is seen that fishes are not reared in the *pukhuris* of Kolongpar hamlet. People of this hamlet are not interested in digging out more *pukhuris.*

Table 3.5: Size and distribution of *pukhuris* in Duboritoli

Size Class (in acres)	Total land (in hectare)	Number of households possessing *pukhuris*
> 0.1	0.581	10
0.1 - 0.2	0.697	5
0.2 - 0.3	0.678	3
0.3 - 0.4	0.335	1
0.4 - 0.5	0.804	2
0.5 - 0.6	0.594	1
< 0.6	0	0
Total	**3.689**	**22**

Source: Field Survey, 2017-2018

Duboritoli *chuburi* has 22 *pukhuris*, out of which majority of them (10) are less than 0.1 hectare in size. To practice fishing for subsistence as well as for commercial purposes, people in this *chuburi* have made the size and depth of their *pukhuris* larger so that they can retain the rain water and the fishes could survive well. Duboritoli accounts for 20.57% of the total area covered by ponds.

Table 3.6: Size and distribution of p*ukhuris* in Salmara Pam

Size class (in acres)	Total land (in ha)	Number of households possessing *pukhuris*

> 0.1	0.178	3
0.1 - 0.2	0.241	2
0.2 - 0.3	0	0
0.3 - 0.4	0.335	1
0.4 - 0.5	0	0
0.5 - 0.6	0.54	1
< 0.6	0	0
Total	**1.294**	**7**

Source: Field Survey, 2017-2018

This *chuburi* has only 8 *pukhuris,* and almost all of them are shallow, and their depths do not exceed more than 6 feet on an average. Their sizes are also very small (mostly less than 0.2 hectare) for which they have low water retaining capacity (depth of less than 2 feet) and ultimately discourage the owners for fish rearing.

Table 3.7: Size and distribution of *pukhuris* in Garhmaj

Size class (in acres)	Total land (in ha)	Number of households possessing *pukhuris*
> 0.1	0.345	6
0.1-0.2	3.484	8
0.2-0.3	1.668	2
0.3-0.4	0	0
0.4-0.5	2.412	6
0.5-0.6	2.16	1
< 0.6	0.67	1

Total	**10.739**	**24**

Source: Field Survey, 2017-2018

Garhmaj has covered the largest area under *pukhuris* having a total number of 46. Out of which about 22 *pukhuris* act as fish breeding centres which are regulated and maintained by the government of Assam. The elevation of this *chuburi* is higher than that of the other *chuburis* due to which water retaining capacity is more in comparison to others. Fishing is practised commercially, and the largest *pukhuri* of the village is found in this hamlet occupying an area of 0.67 hectare (5 *bigha)*. This *pukhuri* was dug in the year 2004 for the requirement of earth for the four-lane highway construction. This *chuburi* covers an area of 10.739 hectares under *pukhuris* accounting for 59.88% of the total area covered by *pukhuris* in the village.

Table 3.8.: Size and distribution of *pukhuris* in Dighaliati

Size class (in acres)	Total land (in ha)	Number of households possessing *pukhuris*
> 0.1	0.35	5
0.1-0.2	0.616	4
0.2-0.3	0.268	1
0.3-0.4	0.3	1
0.4-0.5	0.402	1
0.5-0.6	0	0
< 0.6	0	0
Total	**4.348**	**11**

Source: Field Survey, 2017-2018

It has been found that Dighaliati, located in the south-eastern corner of the village has only 12 *pukhuris* and majority of them is of less than 0.2 hectare size. The owners of the *pukhuris* in this *chuburi* carry out fishing in a profitable way as water does not dry up here. This *chuburi* covers an area of 4.348 hectares under *pukhuris accounting for* s 24.25% of the total area covered by *pukhuris* in the village.

Table 3.9: Size and distribution of *pukhuris* in Kahargaon

Size class (in acres)	**Total land (in ha)**	**Number of households possessing *pukhuris***
> 0.1	1.594	26
0.1-0.2	5.172	21
0.2-0.3	2.614	6
0.3-0.4	0.97	3
0.4-0.5	3.618	9
0.5-0.6	3.294	3
< 0.6	0.67	1
Total	**17.932 (4.71%)**	**69 (23.71%)**

Source: Field Survey, 2017-2018

Thus, after having a thorough observation at the sizes of the *pukhuris* in each of the *chuburis*, it can be concluded that majority of the *pukhuris* of the village are of less than 0.1 hectare size. Only 41 *pukhuris* have their sizes between 0.1-0.2 hectares. The *pukhuris* of the village occupy a total area of 17.932 hectares accounting for 4.71% of the total area of the village.

It is noteworthy that there are as many as 138 households in the village who do not have *pukhuris*. These pond-less people manage to consume fish from the Kolong and Mora-

Kolong rivers and also from the agricultural fields where there have been seen lot of fishes during summer season.

Table 3.10: Number of households in each *chuburi* without having *pukhuris*

Chuburis	**Number of households without *pukhuris***
Kolongpar	24
Duboritoli	54
Salmara Pam	6
Garhmaj	43
Dighaliati	11
Total	**138**

Source: Field Survey, 2017-2018

In Kolongpar, only 3 households possess *pukhuris* of their own. Other families of the *chuburi* do not have *pukhuris*. Similarly, in Duboritoli there are 22 households having *pukhuris* and the rest of 54 households do not own *pukhuris*. In Salmara Pam, Garhmaj and Dighaliati there are 6, 43 and 11 households respectively which do not have *pukhuris* of their own. It is found that most of the households of Kolongpar *chuburi* and northern part of Duboritoli *chuburi* do not have *pukhuris* as because the soils of these *chuburis* consisted of sandy soils which cannot hold water for long period. The infiltration capacity of sandy loamy soils is 0.9 inches per hour (Leopold, Wolman and Miller, 2015). In Salmara Pam, 57.14 % of the total households have *pukhuris* as because some parts of this chuburi have clayey soils that prevent infiltration of water in the *pukhuris*. It is estimated that the clayey soils have an average infiltration capacity of 0.04 inches per hour (Leopold, Wolman and Miller, 2015). Garhmaj is relatively higher in elevation so it cannot hold the surface water for long as water flows according to the slope towards other *chuburis*. Similarly in Dighaliati, the households which are located on the bank of the Mora-Kolong do not have *pukhuris* except for one family. But in the south-eastern corner of the village, i.e. in Dighaliati, there are *pukhuris* that hold water for almost all the year and fishing is carried out there mainly for self-consumption.

Table 3.11: Size and distribution of *khals*

Size class (in acres)	Total land (in acres)	Number of households possessing *khals*
> 0.05	1.364	12
0.05 – 0.1	1.49	8
0.1 – 0.15	0	0
0.15 – 0.2	0	0
< 0.2	0.21	1
Total	**3.064**	**21**

Source: Field Survey, 2017-2018

It is interesting to note that most of the *khals* in the village are smaller, i.e. of less than 0.05 hectares. The *khals* in Kolongpar and Duboritoli remain dry except in the rainy season. The only utilization these *khals* is that people can catch fishes from these *khals* during the summer season. Garhmaj and Dighaliati *chuburis* do not have many *khals*. The only utilization of *khals* in both these *chuburis* is that of fishing during summer months. But interestingly, Salmara Pam has a few *khals* to catch fish and the water of them is used in the agricultural fields.

4) **Mora-Kolong (Dead Channel):** These semi perennial cut-off meander channels are generally formed due to change in river course. However, the Mora-Kolong also known as *morasuti* is an artificially one in the village. The average water level in the *morashuti* during summer months is about 6-7 ft., which goes down to as low as 1.5-2 ft. during the winter season. However, at some places the water level of this dead channel, during peak monsoon months, rises up to 7 ft. This abandoned channel is endowed with many aquatic flora and fauna and thus provides a variety of goods and services to the villagers.

Fig 3.6: A part of Mora-Kolong

This *morasuti* flows through the eastern part of the village for a considerable length. Dead channels always play a significant role in the ecology of a village or an area they have passed through. They help in building up a new kind of riverine ecology which can be termed as *dead channel ecology*. Generally, they become the store-house of a variety of aquatic plants and animals, including fishes. Earlier, the local people sustained their livelihood by utilizing the resources of the dead channel

Table 3.12: Water level of the wetlands in the village

Nature of origin	Type of wetlands	Total no. of wetlands	Average water levels (in feet)		Remarks
			In summer	In winter	
Natural	*Khals*	85	4.9	0.3	Average of all the chuburis have been considered
	River Kolong	1	49.5	4.5	Average at different parts have been considered
	Morasuti	1	9.4	2.2	
	Beel	2	3.3	1.3	
Man-Made	*Pukhuris*	120	8.62	3.4	Average of all the chuburis have been considered
	Tube Well	284	29.28		
	Ring Well	1	-7.5	-14.5	Water level from the surface has been taken into account

Source: Field Survey, 2017-2018

5) ***Hola* (Shallow Depression):** These are shallow depressions, which act as the seasonal wetlands as they contain water, especially during the rainy season. As such, they are also called as floodplain wetlands. Only one *hola* could be traced out in the village, and at present, it has been converted into *pukhuri* by further digging.

Table 3.13: Hydrological attributes of wetlands in each *chuburi*

Name of *chuburis*	**Types and no. of wetlands**			**Total no. of wetlands**	**Average water level (in feet)**
	***Pukhuri* (*P*)**	***Khal* (*Kh*)**	***Beel* (*B*)**		
Kolongpar	3	8	0	11	P=9.6, Kh=5.6, K=47.5,
Duboritoli	25	30	0	55	P=12.01, Kh=5.8, K=51.5, MK=11.3
Salmara Pam	8	11	2	19	P=8.3, Kh=5.1, B=3.3
Garhmaj	66	11	0	77	P=8.29, Kh=4.8,
Dighaliati	18	25	0	43	P=4.91, Kh=3.2, MK=7.5
Total	**120**	**85**	**2**	**205***	**-**

Source: Field Survey, 2017-2018

6) ***Pitoni* (Marsh):** These are wet spongy grounds having a considerable level of water and usually covered by aquatic vegetation. Arum (*kosu)* plants and water lilies are the common plants found there. A few such *pitonis* have been found in the village.

7) ***Doloni*** **(Swamp):** When the rain or floodwater gets concentrated on the very low-lying agricultural fields during summer they are called as *dolonis.* They also become the temporary habitats for many small fish species and aquatic animals. There are two significant *dolonis* in the village, which are located in Salmara Pam *chuburi.* One is named as *Kherxona* and another one is called as *Hatigeya.* These *dolonis* were actually the *baotolis* of the village. However, these are actually *dolonis* but people refer to them as *beel*.

Table 3.14: Monthly variation in water level of each wetland in Kolongpar

Months	**Average water level (in feet)**		
	Pukhuri	***Khal***	**Kolong**
January	0.5	-	24.0
February	-	-	23.0
March	-	-	16.3
April	2.5	1.2	24.3
May	5.3	2.4	34.5
June	7.6	3.2	42.6
July	9.4	4.4	48.5
August	7.5	3.6	44.3
September	4.2	2.4	37.5
October	2.5	1.2	33.8
November	2.0	0.7	29.2
December	1.3	0.2	26.5

Source: Field Survey, 2017-18

Kolongpar being located on the south of the river Kolong in the northernmost part of the village exhibits unique hydrological characteristics. As mentioned earlier, water in the wetlands of this *chuburi* does not retain for long period. It eventually dries up or flows internally as soon as the water level of the Kolong River subsides. The water level of the

Kolong as well as the wetlands rises high in the month of July while it goes down gradually from September. It is important to note that the water level of the wetlands in September goes down to less than half of that in July. Even during the driest months of the year, i.e. in February and March, the water of the wetlands, especially *pukhuris* completely dry up. On the other hand, the water of the *khals* dries up completely from the month of January to March. However, with the onset of pre-monsoon season (from April), the water starts accumulating in these wetlands.

The water level of the Kolong river emerge up to 48.5 feet in July which gradually starts decreasing from September and becomes lowest (16.3 feet) in the month of March.

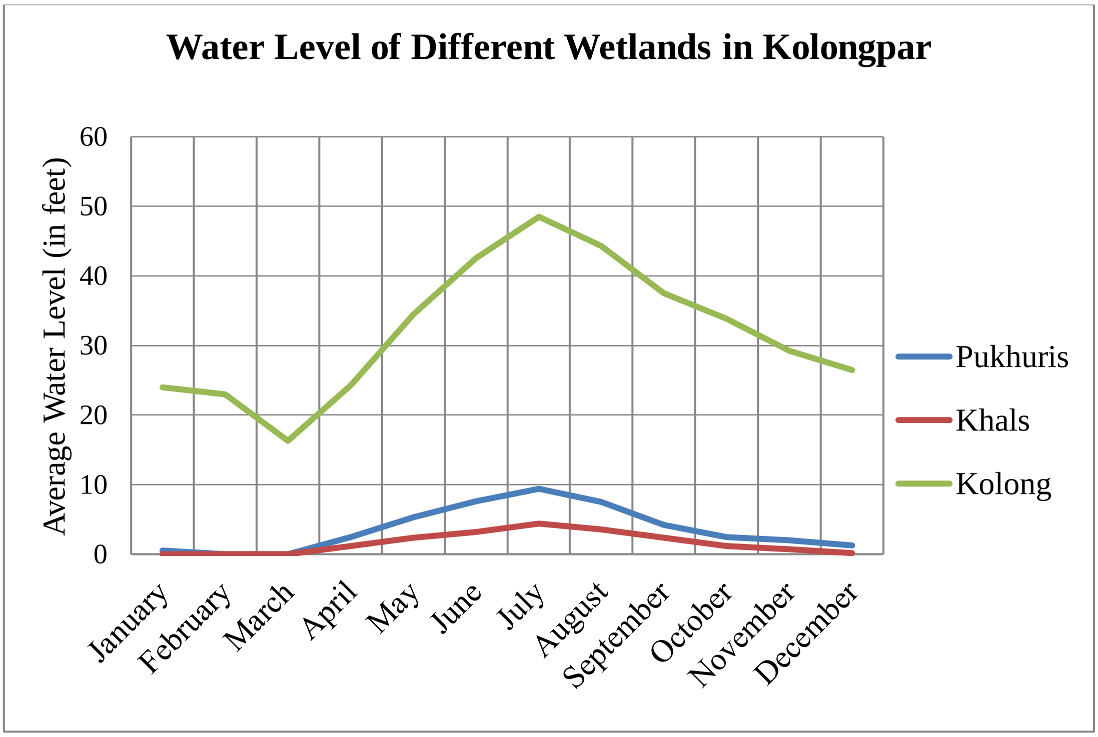


Fig. 3.7: Water level of wetlands in Kolongpar

The hydrological characteristics in Duboritoli are different from other *chuburis* in the sense that this *chuburi* has both Kolong and Mora-Kolong attached to it. Except the *khals*, no wetlands in the chuburi dry up completely even during the driest months. The *khals* however, dry up completely during February-March.

Table 3.15: Monthly variation in water level of each wetland in Duboritoli

Months	Average water level in feet			
	Pukhuri	***Khal***	**Kolong**	**Mora-Kolong**
January	1.8	0.5	26.5	1.7
February	1.2	-	23.0	1.2
March	0.5	-	16.3	0.8
April	3.5	1.8	24.3	2.0
May	4.3	2.4	34.5	2.5
June	6.2	3.5	42.6	3.8
July	8.6	4.5	48.5	4.5
August	7.0	3.4	44.3	3.8
September	6.2	2.7	37.5	3.3
October	5.5	2.3	33.8	3.0
November	4.3	1.5	29.2	2.6
December	2.5	1.2	24.0	2.2

Source: Field Survey, 2017-18

The average water levels of the *pukhuri*, Kolong and Mora-Kolong are highest in the months of July, which stand at 8.6, 48.5 and 4.5 feets respectively. The water level continues to decrease, as there is dearth of rainfall from the post-monsoon months. However, the water levels of the *pukhuris*, Kolong and Mora-Kolong are lowest in the month of March i.e. 0.5, 16.3 and 0.8 feets respectively.

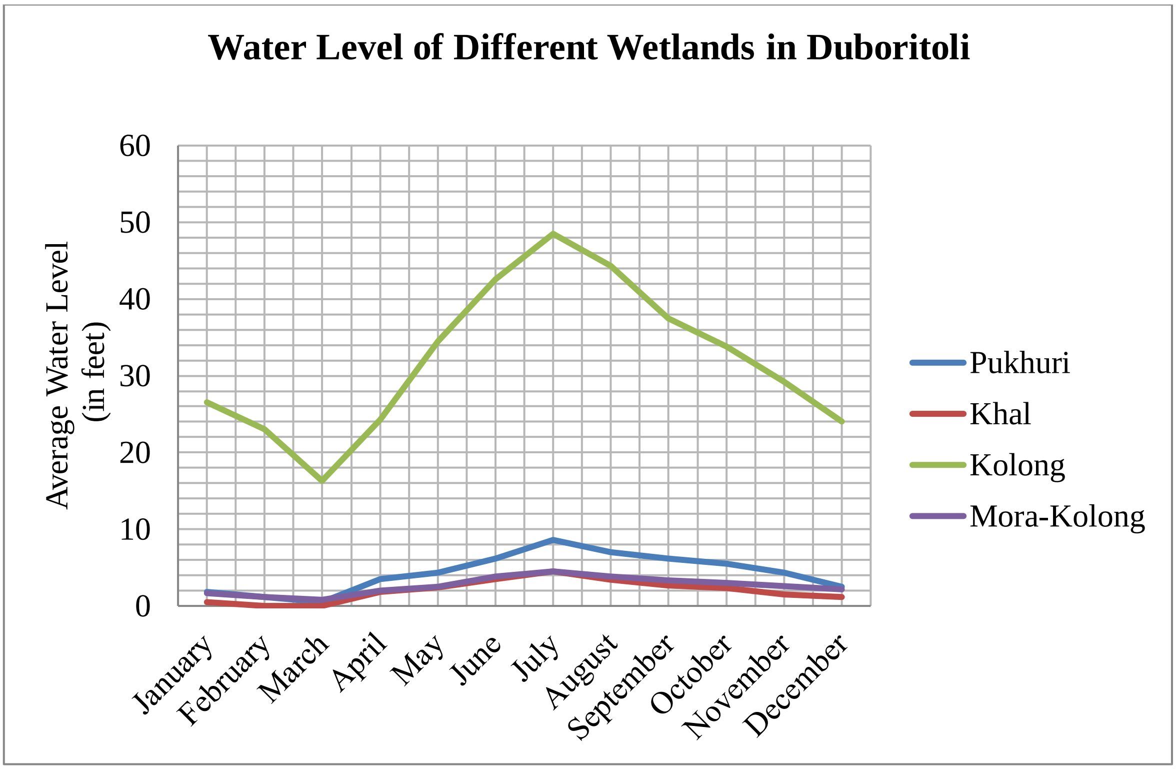


Fig. 3.8: Water level of wetlands in Duboritoli

In Salmara Pam, along with the *pukhuris* and *khals*, there are two *beels*, called *Kherxona* and *Hatigeya* where the water level average stands at 3.3 feets. The water level of the *pukhuris* and *khals* is highest in the months of July and August, where the water stands upto the height of 8.8 feet and 4.4 feet respectively. Contrary to this, the water level of the *pukhuris* and *khals* decreases as soon as the monsoon starts retreating.

Table 3.16: Monthly variation in water level of each wetland in Salmara Pam

Months	**Average water level (in feet)**		
	Pukhuri	***Khal***	***Beel***
January	2.3	1.0	
February	1.3	0.5	
March	-	-	
April	2.5	1.3	
May	4.3	2.4	
June	6.6	3.5	
July	8.8	4.4	
August	7.6	3.1	

September	6.2	2.6	
October	5.5	2.0	
November	4.3	1.5	
December	3.5	1.2	

Source: Field Survey, 2017-18

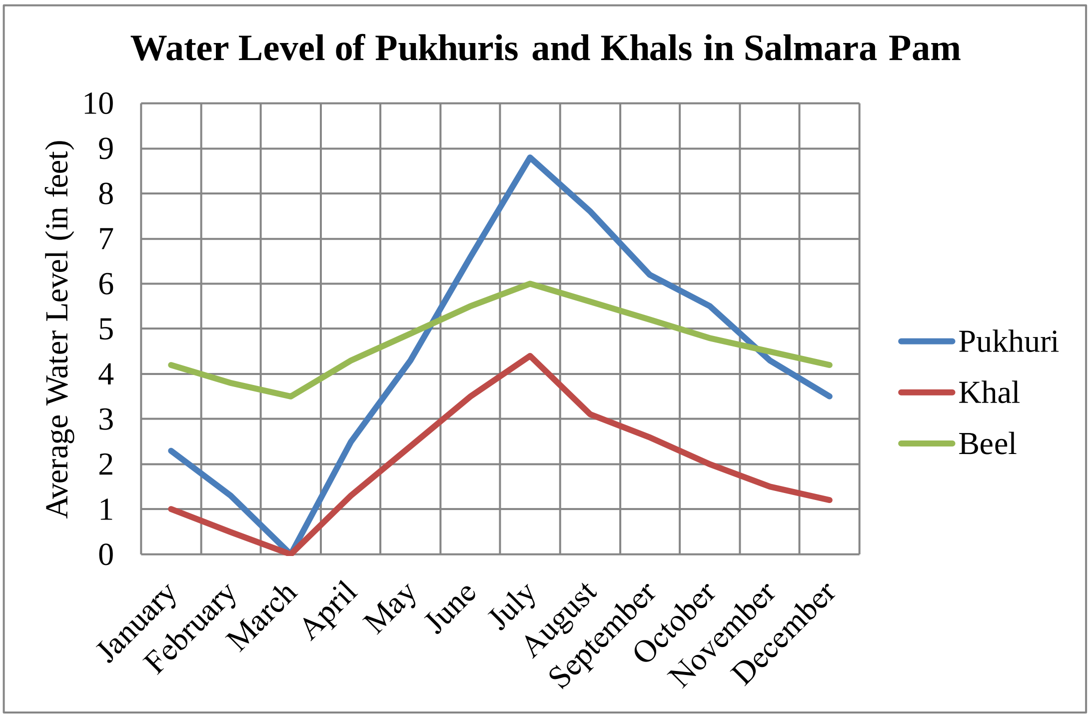


Fig. 3.9: Water level of wetlands in *Salmara Pam*

Garhmaj, located in the southern part of the village is not adjacent to the Kolong and Mora-Kolong so, the water of the *pukhuris* and *khals* does not dry up even during the driest months of the year.

Table 3.17: Monthly variation in water level of each wetland in Garhmaj

Months	**Average water level (in feet)**	
	Pukhuri	***Khal***
January	4.5	1.5
February	4.0	1.3
March	3.2	0.5

April	5.5	1.3
May	6.3	2.5
June	8.2	4.3
July	9.6	5.5
August	8.8	4.8
September	7.9	3.9
October	6.5	2.6
November	5.6	2.2
December	5.0	1.8

Source: Field Survey, 2017-18

However, the water level of the wetlands in the *chuburi* is highest in July, which is 9.6 feet in the *pukhuris* and 4.3 feet in the *khals*. During March, the water level goes down to 3.2 feet in the *pukhuris* and 0.5 feet in the *khals*

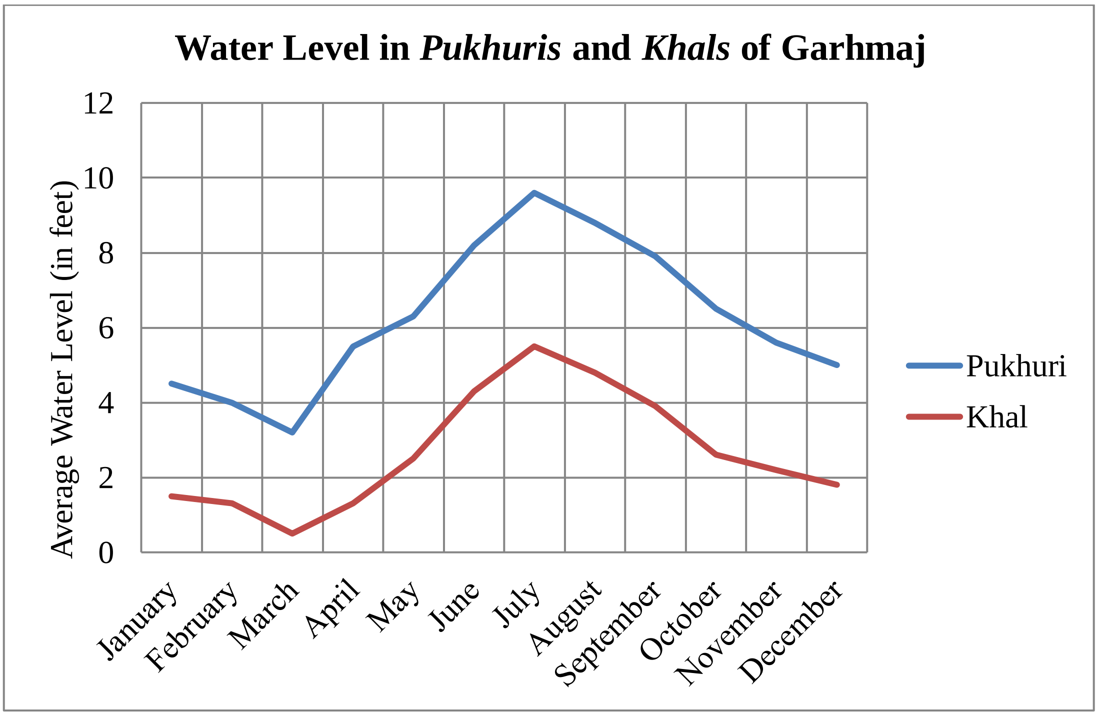


Fig. 3.10: Water level of wetlands in Garhmaj

The water level of the *pukhuris, khals* and Mora-Kolong in Dighaliati is highest in the month of July and lowest in March. In July, the water level is 6.9 feet in the *pukhuris*, 4.5 feet in *khals* and Mora-Kolong. On the other hand, the water level is 2.2 feet in *pukhuris* and 0.8

feet in Mora-Kolong. It is noteworthy that, the water in the *khals* completely dry up in the month of March.

Table 3.18: Monthly variation in water level of each wetland in Dighaliati

Months	**Average water level (in feet)**		
	Pukhuri	***Khal***	**Mora-Kolong**
January	3.5	1.0	1.7
February	2.8	0.5	1.2
March	2.2	0	0.8
April	3.5	2.0	2.0
May	4.8	3.1	2.5
June	5.7	4.0	3.8
July	6.9	4.5	4.5
August	6.2	4.3	3.8
September	5.6	3.6	3.3
October	5.0	2.5	3.0
November	4.7	2.1	2.6
December	4.0	1.5	2.2

Source: Field Survey, 2017-18

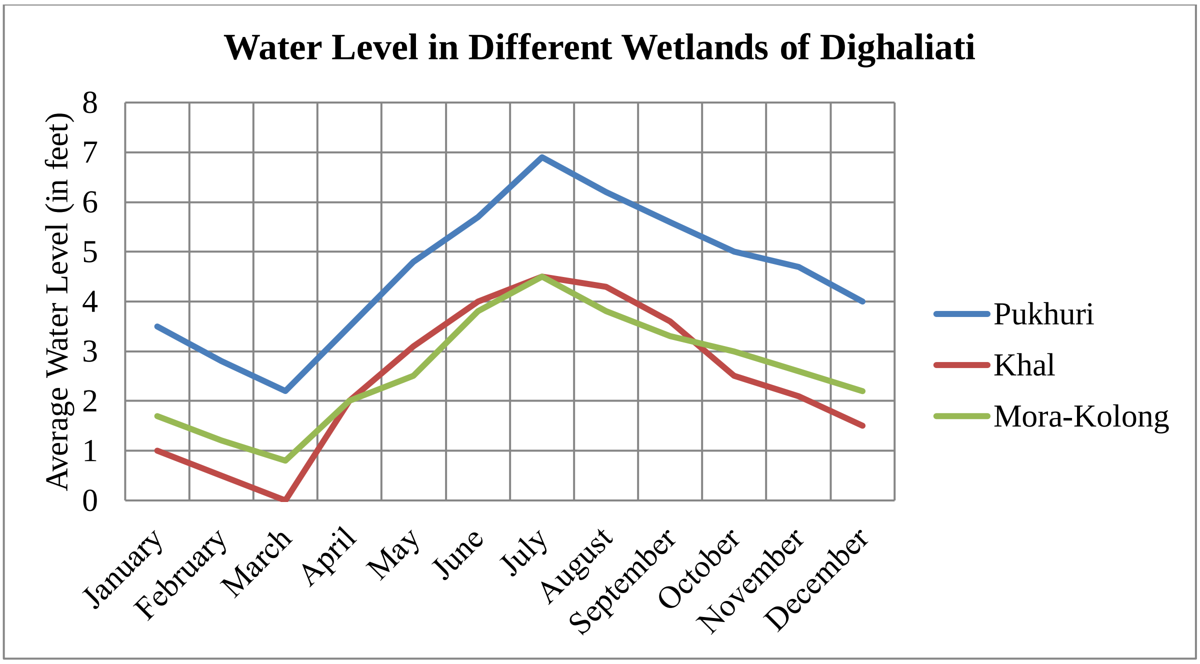


Fig. 3.11: Water level of wetlands in Dighaliati

3.6 Ground Water Status

Unlike the urban areas, the groundwater level in the rural areas of the Brahmaputra valley is found to be still very high. However, there is a marked variation in groundwater level in different rural areas of the valley because of the differences in physiographic conditions, surface elevation, pedological conditions and drainage density and frequency status. It is seen that because of the variation in ground water status, the nature of water utility pattern, water resource management system, land use and cropping pattern, etc. are also different in the valley. It is observed that because of the unplanned construction of embankments and roads and shifting of river course with concomitant degradation of natural wetlands, groundwater level in many areas has also started subsiding.

The ground water status of Kahargaon is assessed by observing the water level of tube wells and wells. The ground water level varies in different seasons and in different parts of the village. During the summer season, because of the rise of the riverbed, saturation of soil moisture and abundance of rain, the ground water level naturally rises. It is found that there is a marked variation of groundwater level within the village as observed in each *chuburi* (Table 2). Kolongpar and Duboritoli, being located closer to the Kolong river have higher groundwater level. On the other hand, though Salmara Pam is located away from both the Kolong and Mora-Kolong, the existence of a number of wetlands, like *beels*, *khals*, *pukhuris*, etc. in this *chuburi* has helped in maintaining higher level of groundwater.

Table 3.19: Ground water level

Chuburis	**Average groundwater level (in feet)** (using tube wells)
Kolongpar	18.5
Duboritoli	24.2
Salmara Pam	19.8
Garhmaj	26.6
Dighaliati	57.3

Source: Field Survey, 2017-2018

Again, despite having higher surface elevation of Garhmaj *chuburi* than the other *chuburis*, it has comparatively higher groundwater level because of the presence of a large number of *pukhuris*. However, it is interesting to note that Dighaliati *chuburi*, despite having lower elevation than Garhmaj has lower groundwater level as because this *chuburi* is detached from both the Kolong and Mora-Kolong river due to which water from the river cannot flow onto this *chuburi* and help in recharging groundwater.

Table 3.20: Status of ground water using ring wells

Months	**Average water level in ring wells from the surface level (in feet)**	**Average water level from Mean Sea Level (MSL) (in meters)**
January	-14.5	44.3
February	-15.2	43.6
March	-16.8	42.0
April	-12.6	46.2
May	-10.5	48.3
June	-9.9	48.9

July	-7.5	51.3
August	-9.5	49.3
September	-10.7	48.3
October	-11.4	47.4
November	-12.5	46.3
December	-13.3	45.5

Source: Field Survey, 2017-18

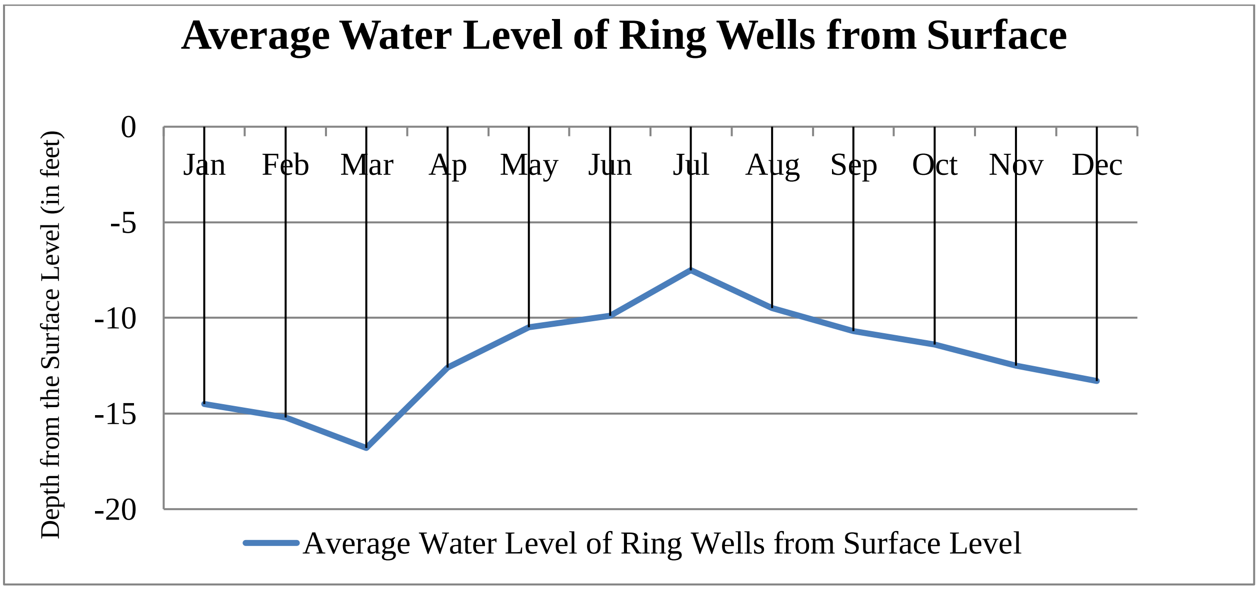


Fig. 3.12: Status of groundwater using ring wells

Thus, people have installed ring wells in places where the underground water level is high and tube wells are installed in those places where the underground water level is low. With the installation of tube wells, people have access to drinking water even in those areas where the underground water level is low. These variations in groundwater level have also caused variation in land use pattern and land cover status within the village.

3.7 Surface and Sub-Surface Water Quality

The gradual decrease in the species of many aquatic plants and fishes has been the result of increasing human intervention and their impacts on the earth's surficial water storages. Such a condition demonstrates a developing crisis in near future if the wetland resources are not properly managed (Charkhabi and Sakizadeh; 2006 and Peters and Bricker, 1997). Water quality is an important indicator of the status of water in a wetland. The water quality of wetlands is primarily a result of geologic setting, water balance (relative proportions of inflow, outflow, and storage), quality of inflowing water, type of soils and vegetation, and human activity within or near the wetland (Carter, 1996).

In the present study, the water quality parameters have been selected in such a way that these parameters clearly reflect the ecological status of the sampled wetlands. Therefore, only ecological parameters have been considered (Table 3.21). It has been found that the tolerable temperature for the fishes is 30°-35° C (Delince, 1992 and the temperature of the water of the wetlands are suitable for pisciculture in this regard.

It has been found that the pH of water in Kolong is 6.79, Mora-Kolong is 6.57, *pukhuris* in Salmara Pam and Dighaliati are 6.83 and 6.88 respectively and in the selected *khals* in Garhmaj and Dighaliati the values are 6.62 and 6.79 respectively. As the acceptable range for fish culture is 6.5-9.0 (Swann, 1997), thus all the sampled wetlands in the village has suitable pH conditions.

ORP (Oxidation-reduction potential or Redox potential) is used to measure the effectiveness of water disinfection sanitizers or a measure of the total oxidizing capability (electrochemical potential) that the solution has (Lambrou, 2011). It is a measurement, which shows that higher the ORP, higher are the potential of that wetland's water to kill bacteria. It has been found that the sampled wetlands in the village has lesser ORP, Kolong (266 mV), Mora-Kolong (78 mV), *pukhuri* in Salmara Pam (179.6 mV), *pukhuri* in Dighaliati (28 mV) and *khal* in Garhmaj (79 mV). If ORP is between 150-250 mV, it suitable for practicing aquaculture and it is more than 600 mV, and then it is suitable for drinking. It should be noted that tougher organisms such as listeria, yeasts and molds may require 750 mV or higher in order to be killed (Lambrou, 2011).

The desirable limit of electrical conductivity is 60-2000 µS/cm and it has been found in the village that the sampled wetlands have the value within the desired limits, so there is nothing much to be concerned about it. Electrical conductivity also can be used to give a rough estimate of the total amount of dissolved solids (TDS) in water. Typically, the total dissolved solids value in mg/L is about half of the electrical conductivity (Stone et *al*., 2013).

Salinity of water in wetlands affects the density and growth of aquatic organisms (Jamabo, 2008).Fishes like common carp has a desirable range 2 ppt (Bhatnagar and Devi, 2013); however, Bhatnagar et al. (2004) gave different ideal levels of salinity as 10- 20 ppt for *P. monodon*; 10-25 ppt for *euryhaline* species and 25-28 ppt for P. *indicus*. Barman et al. (2005) gave a level of 10 ppt suitable for *Mugil cephal*. However, salinity is low in the wetlands of the village not exceeding more than 0.12 ppt.

The desirable limit for TDS in wetlands is upto a maximum limit of 1000 mg/L or 1 g/L (Rahmanian et *al.*, 2015). It is found that wetlands in the village are within the desirable limit of TDS that ensures suitable conditions for pisciculture.

The tolerable limit of dissolved oxygen (DO) is estimated at 3-6 mg/L, and the desirable limit is less than 5 mg/L (Bhatnagar and Devi, 2013). The sampled wetlands in the village have a less than the desirable limit except the river Kolong that has 5.87 mg/L.

Table 3.21: Water quality of surface water, 2018

Name of the sources of surface water		**Kolong**	**Mora-Kolong**	***Pukhuri* (Salmara Pam)**	***Pukhuri* (Dighaliati)**
Coordinates of the sampled sources		26°12’47’’N/ 92°28’8’’E	26°12’25’’N/ 92°29’24’’E	26°12’26’’N/ 92°29’2’’E	26°12’25’’N/ 92°29’24’’E
Parameters of Water Quality	Temp [°C]	29.38	28.61	28.47	28.56
	pH [Units]	6.79	6.57	6.83	6.88
	ORP [mV]	266	78	179.6	28
	SpCond [µS/cm]	216	249	0	0
	Sal [ppt]	0.1	0.12		-0.02
	TDS [g/l]	0.1	0.2	0	0
	LDO [mg/l]	5.87			
	Chlorophyll [µg/l]	0	0	0	154.78
	Phycocyanin [cell/mL]	335	2,106.66	3177.33	21,693.66

Source: Field Survey and Laboratory Test, 2018

Table 3.22: Water quality of sub-surface water, 2018

Name of the sources of underground water		Tube Well (Kolongpar)	Tube Well (Duboritoli)	Tube Well (Salmara Pam)	Tube Well (Dighaliati)
Coordinates of the sampled sources		26°12''42'N/ 92°28''3'E	26°12'26''N/ 92°29'2''E	26°12'47''N/ 92°28'8''E	26°12'25''N/ 92°29'24''E
Parameters of Water Quality	Temp [°C]	29.14	25.56	28.48	28.59
	pH [Units]	6.58	6.89	6.62	6.81
	ORP [mV]	248	235	268	296
	SpCond [µS/cm]	205	0	171.6	403
	Sal [ppt]	0.09	-0.02	0.08	0.2
	TDS [g/l]	0.1	0	0.1	0.3
	LDO [mg/l]	0.98	0.98	3.3	
	Chlorophyll [µg/l]	0	0	0	0
	phycocyanin [cell/mL]	196	83.66	0	274.75

Source: Field Survey and Laboratory Test, 2018

3.8 Ecohydrology

It is interesting to note that the hydrological conditions have played immense role in enhancing biological diversity and maintaining ecological balance in the rural landscapes of the Brahmaputra valley. There is a good relationship between the hydrological conditions and the ecological diversity of the village. Different hydrological conditions have given rise to different ecological settings of an area. It is worth mentioning here that different types of wetlands and even the agricultural fields in summer season become the habitats of different types of aquatic plants and animals, including insects. The biological diversity that prevails in rivers is different from that of dead channels, swamps, marshes, ponds and *beels*.

The ecology in the river Kalong is quite different from that of a dead channel. The river Kalong is rich in fish species and as it has more water discharge. On both the banks, the grasses locally known as *kohua* (*Saccharum spontaneum*) and *jau bon* are abundantly found which are naturally grown. The unique feature of *jau bon* is that its roots are quite long which measures about 2 to 3 feet. It thus, holds the soils firmly and prevents the bank from erosion. The bank of dead channel, on the other hand, is quite rich from the viewpoint of biodiversity. Dead channels always play a significant role in the ecological richness of a village. They help in evolving a new kind of riverine ecology. Generally, they become the store-house of variety of aquatic plants and animals, including birds that feed on the fishes and insects. The dead channel of Kolong flows through the eastern part of the village creating congenial conditions for various ecological habitats. Various types of grasses are found on the river when its water dries up. Varieties of fishes are found in the wetlands of the village, some of which are much endangered now. The common fish species found in the village are *sol, magur, goroi, singi, kandhuli, kawoi, puthi, borali, kuhi, mirica, dorikona, sal, bheseli, ged-gedi, muwa, dhekera, rohu , selekona, grasscarp, tura, cuchia, boti kora, patit mutura, misa maas, sengeli, chanda, chital, seniputhi* and *eleng*. Besides, many birds come to the bank of the wetlands to eat fish and insects. The most common birds seen on the wetlands are crane (*bogoli*), *dauk*, *pani kauri*, *masruka, etc.* Earlier, the local people sustain their livelihood by utilizing the resources of the dead channel-Kolong. The people mostly consume fishes, sell them and use the water of the river for various purposes.

Table 3.23: Selected fishes and their common habitats and status

Sl. No.	**Fishes and their common habitats and status**			
	Local name	**Scientific name**	**Habitat**	**Status**
1	Naro			A
2	Bhangon	Labeo bata	K, *P*	A
3	Puthi	Puntius sophore	MK, *Kh, B*	A
4	Mirica	Cirrhinus mrigala	K, MK, *P*	A
5	Kuhi		*P*	A
6	Borali	Wallago attu	K, *P*	R
7	Bherengoni		K, MK	R
8	Pabho	Ompok bimaculatus	K, MK	R
9	Bato		K, MK	R
10	Misa		MK, K	R

11	Borduali		K, MK	R
12	Tingora	Mystus tengara	MK	R
13	Bangi		K, MK	R
14	Koliajara		K, MK	R
15	Kandhuli	Notopterus notopterus	*P*, MK	A
16	Grass carp	Ctenopharyngodon mola	*P*	A
17	Rou	Labeo rohita	K, *P*	A
18	Aarie	Aorichthys seenghala	K, MK	R
19	Neria		K, MK	R
20	Gagol	Mystus cavasius	K	R
21	Besa	Setipina phasa	*Kh*, K, MK	R
22	Bagh Maas		K, MK	R
23	Kokila Dora		K, MK, B	R
24	Patit Mutura	Glossogobius gutum	K, MK, B	R
25	Dhul Bari		K, MK	R
26	Boti Kora		K, MK	R
27	Bhedengi		K	R
28	Lau Pati	Chela cachius	*Kh, MK*	R
29	Goroi	Channa punctatus	*Kh*, MK, *Pi*	R
30	Sengeli	Channa gachua	*Kh*, *Pi*	R
31	Kholihona	Colisa fasciata	*Kh*, *B*	A
32	Bhed Bhedi		*Kh*, *B*	A
33	Sol	Channa striatus	MK, *Kh*, *B*	A
34	Kawoi	Anabas testudineus	*Pi*, *Dol*, *Kh*	R
35	Boriyola	Barilius barila	K, MK	R
36	Dorikona	Esomus danricus	MK, *Kh*	R
37	Dhekera		*P*,	A
38	Singora			R
39	Muwa	Ambiypharyngodon mola	K, MK	A
40	Elengi		K	R
41	Singi	Heteropneustes fossilis	*Dol*, *Pi*, *Kh*	R

42	Beregi		K	R
43	Ritha		K	R
44	Mali		K	R
45	Common Carp	Cyprinus carpio	*P*, K	A
46	Bheseli	Colisa colisa	B, MK	A
47	Selekona	Chela atpar	MK, B, *Kh*	R
48	Seni Puthi			A
49	Chital			R
50	Tura	Macrognathus aral	*Kh, B*	R
51	Kuchia	Monopterus cuchia	*Dol, Pi,* MK	R
52	Tora	Macrognathus aral	*Kh, B*	R
53	Japani Puthi			A
54	Hod-Bhedeli		K, MK	R
55	Silver Carp	Hypothalmichthys molitrix	*P*	A
56	Magur	Clarias magur	*Pi, Dol, Kh*	R
57	Thailand Magur			A
58	Koria		K, MK	R
59	Katol			R
60	Chanda	Chanda nama	K, *Kh, B*	A
61	Bodua		K, MK, *Kh, B*	R
62	Gulsa		K, MK	R
63	Bhedesi		K, MK	R

Source: Field Survey, 2017-2018; Note: K- River Kolong, MK- Mora-Kolong, *P- Pukhuri, Kh- Khal*, B-Beel, *Pi- Pitoni, Dol- Doloni*

Pukhuris (ponds) and *khals* are the other important components of the village hydrological environment which have hold a significant place in the concerned ecological settings. The *pukhuris* and *khals* are the sources of fishes and other aquatic animals and plants. People dug *Pukhuris* to rear some fishes. Again *khals* are the sources of a large number of wild fishes, like *borali, sengeli, kawoi, goroi, sol, magur, singi, besa, puthi, chanda, dorikona, uparsakuwa, tingara, etc*. Many insects and birds feed on the fishes and insects of the *pukhuris* and *khals*. Thus, the *pukhuris* and *khals* have in many cases played equal role with other wetlands in maintaining the rural ecological balance. Again, on the banks of the *khals*, many edible and non-edible plants are found. The important edible plants are *dhekia*, *helesi*, *kolmou (Ipomoea aquatica)*, *spinach (Spinacia oleracea)*, *khutoria*, *mani-muni*, *bhedai lota*, *mati kaduri*, *boga kosu*, *nol kosu*, *lotus*, water lilly, *mukua*, *ikora*, etc. Again, various types of tress grow either naturally or are planted by the villagers on the banks of the *pukhuris* and *khals*. Banana trees are most common among them.

Fig. 3.13: Banana trees planted on the banks of *pukhuris*

It is quite interesting to note that, the autumn and the winter rice fields act as seasonal wetlands whose contribution to the ecology of the village is quite significant. In the autumn rice fields, after harvesting the rice, different types of plant species, such as *khutoria*, *mani-muni*, *helesi*, *mukua*, etc grow naturally, of which some are edible ones. It is noteworthy that, rain water in some *salitolis* (winter rice fields) and *baotolis* remain concentrated for at least 4 to 5 months. The winter rice fields have also provided firtile ground for the growth of different types of *bon* (grass), *saak* (edible plants). These rice fields, during summer become temporary habitats of wild fishes, many aquatic living beings such as *kekura* (crab), snake, *bhekuli* (frogs), *beng* (toad) and also of some birds like *sarali*, *dauk*, etc. In the *bao* rice fields, apart from a variety of fishes and other aquatic plants, different typesbirds such as *hargila*, *bogoli*, *sarali*, *konamuchari*, *maasroka*, *panikauri*, *samukbhanga* along with some other aquatic species like *kekeura*, *beng*, *bhekuli*, etc. are commonly found which contribute immensely to the ecology of the village. Thus, it has been seen that the hydrological conditions of the village has obvious impacts and influences on its biological diversity.

Table 3.24.: Status and distribution of plants

Local name	Scientific name	Nature	Distribution	Status
Bor mani-muni		Edible	WRF, ARF, *P*	A
Xoru mani-muni		Edible	WRF, ARF, *P*	A
Kolmou	*Ipomoea aquatic*	Edible	WRF, ARF, BRF	A
Helochi	*Enhydra fluctans*	Edible	WRF, BRF,*P*	A
Leheti	*Renunculus sceleratus*	Edible	WRF	R
Morolia		Edible	ARF	R
Makua		Edible	BRF	R
Seleku		Edible	BRF	R
Sesu			BRF	R
Mati kaduri	*Alternanthera sessile*	Edible	*P*	A
Keharaj	*Eclipta prostrate*	Edible	*P*	R
Long bon		Non-edible	WRF	A
Kurxola bon		Non-edible	WRF	A

Erali bon	*Leersia haxadra*	Non-edible	WRF, ARF	A
Binoi		Non-edible	ARF	R
Bor puni	*Salvania natans*	Non-edible	*P*	R
Soru puni	*Lemna perpusilla jorney*	Non-edible	*P*	A
Pani meteka	*Monocharia vaginalis*	Non-edible	*P, Kh,MK,K*	A
Bih-meteka	*Eichhornia crassipes*	Non-edible	*P, Kh,MK,K*	A
Gendhali bon		Non-edible	*P*	A
Banhpotia ghanh		Non-edible	*P*	R
Bhet	*Nymphaea stellata wild*	Non-edible	*Kh, MK*	A
Ronga bhet	*Nymphaea rubra*	Non-edible	*Kh,MK*	R
Boga bhet	*Nymphaea lotus*	Non-edible	*Kh,MK*	R
Bihlogoni	*Polygonaceae*	Non-edible	*P, Kh, MK*	A
Padum	*Nellumboo nucifera*	Non-edible	*Kh, MK*	R
Kuhila	*Aeschynomene aspera*	Non-edible	*MK, K, Pt*	R
Dol ghanh	*Nymeneche assamicanith*	Non-edible	*MK, K*	R
Pati doi	*Schumannianthus*	Non-edible	*MK, Pt*	R

	dichotoma			

Source: Field Study, 2017-2018

Note: WRF- Winter rice field, ARF- Autumn rice field, BRF- Bao rice field; *P- Pukhuri*, *Kh- Khal*, *K-* Kolong, *MK- Mora-Kolong, Pt- Pitoni*; A- Available, R- Rare

Table 3.25: Status and distribution of birds

Local name	Scientific name	Status
Masroka nila	*Alcedo atthis*	R
Masroka tikonithoka	*Ceryle rudis*	R
Bogoli	*Egretta garzetta*	A
Bortokola	*Leptoptilos dubius*	R
Dawok	*Amaurornis phoenicurus*	A
Pani Kauri	*Phalacrocorax niger*	R
Konamusori	*Ardeola grayii*	R
Sorali	*Dendrocygna javanica*	R
Balimahi	*Motacilla alba*	R
Chiloni	*Milvus migrans*	R
Haargilla	*Leptoptilos dubius*	R
Samukbhonga	*Anastomus oscitans*	R
Kaamsorai	*Chlidonias hybrid*	R
Dolmora	*Vanellus indicus*	R

Kukuha	*Centropus sinensis*	R
Moniwori	*Anhinga melanogaster*	R
Hudu	*Bubo bubo bangalensis*	R
Loriyuli	*Pluvialis apricaria*	R
Dolpunga	*Metopidius indicus*	R
Fechu	*Dicrurus adsimilis*	R

Source: Field Survey, 2017-2018; Note: A- Available, R- Rare

Chapter IV

CHANGES IN RURAL HYDROLOGICAL ENVIRONMENT AND UTILITY PATTERN

4.1 Nature of Change

The landscapes of a region are the results of dynamic interaction between the concerned physical and cultural elements. As the interaction between nature and man is dynamic, the changes in the landscapes are obvious. With the changes in natural landscapes caused mainly by human intervention, and concomitant alternation of hydrological environment the people of rural areas of the Brahmaputra flood plains try to adapt to the changing hydrological environment by changing land use pattern and practices.

The hydrological conditions of Kahargaon village have undergone drastic changes. Each component of the hydrological settings of the village has been changing to a large extent. The river Kolong, which originally flowed from the south-eastern corner and at present borders the village in its eastern and northern side, was dug by the government of Assam leaving aside its meandering bend. As the local people were suffering from frequent floods of the Kolong, so the State Government in the 1970s joined both the ends of the meandering channel to lessen flood intensity. The part of the Kolong which is left out is called as Mora-Kolong or *morasuti*. This *morasuti* was once the home of abundance of fish species and aquatic plants. But with the passage of time, many species have become endangered and some of them are going to be extinct.

The trend of living in nucleated family instead of joint family has led to increase in the number of households. Earlier, as people lived in joint families. So, they had large farmlands and larger residential areas. But it is interesting to note that, due to lack of available land and increase in the number of households, people have started settling even on the winter paddy fields. Again, with the increase in the number of human settlements, the number of ponds or *pukhuris* has also been increasing. The lowlands are filled up with soil from other places to build houses. The *khals* have been filled up for the construction of roads as mentioned earlier. In the name of construction of four lane highways after 2004, many *pukhuris* and *khals* were buried. Besides, many of the old and large tress has also been cut down owing to its construction. There were many wetlands, which have been separated by the four lane highways as it passes through them. Many culverts have been lifted up and no any other linkages have been set up in between the fragmented wetlands.

The *pitonis* and *dolonis,* which favor the luxuriant growth of a large variety of grasses, become the important sources of fodder for domestic animals. The grasses were used as fodder for animals. Due to irregularities in rainfall, the *pitonis* sometimes are dried up and it made the grasses and edible vegetables much drier.

The wetlands of the village were earlier used by the people for fishing, bathing, washing clothes and utensils, soaking seeds of crops, some building materials and jute plants, drinking water for themselves and also for their cattle. However, with the onslaught of time, such utilization of the wetlands is rarely seen. Earlier, people had to walk for a long distance to procure drinking water and also for other household purposes. The ecology was very rich before 1970s, but afterwards due to increasing human intervention, the ecology of the village is being degraded. The number of fish species and birds were very high. Even a number of wild animals were also found in the village. However, now many of the species are becoming extinct and some become vulnerable. Earlier, when the siever is once dipped into the water of the river Kolong for washing rice, many fishes come up in the siever (*saloni)* itself.

Table 4.1: Changes in utility pattern of the rivers and wetlands

Components of rural hydrology	**Past status (before 1980)**	**Present status (after 1980)**	**Consequences**
River (*nodi*)	Fishing, bathing, source of drinking water for man and animals, sightseeing, etc.	Fishing and sight seeing	Less interaction between man and the river.

Pukhuri	Domesticate fishes	Increase in number	Increase in domestication of fishes.
Pitoni and Doloni	Different types of grasses accommodating small animals and birds.	Replaced with houses and converted to agricultural lands due to increasing settlements.	Loss of thatch, species of birds and animals.
Mora-Kolong	Fishing, bathing, source of drinking water for man and animals, soaking of rice saplings, etc. Flow was natural with no human intervention.	Agriculture practice, Soaking of rice samplings, and often fishing. Flow has almost been stopped due to building of a road over it with only one very small pool.	Decrease in fish production, birds, etc.

Source: Field Survey, 2017-2018

4.2 Nature of Change in Input-Output System

With changes in environmental conditions over time and across the Brahmaputra valley, the hydrological system has undergone changes in the village. There has been changes in both the input and output mechanisms of water. The river Kolong which once flowed through the northern part of Dighaliati is no longer the main channel as both the meandering ends at Duboritoli were joined together in the early 1970s and the channel that flowed through Dighaliati was turned into a dead channel called Mora-Kolong. Thus, it changed the flooding scenario in Dighaliati.

As far as output of water is concerned, earlier the water of the village flows into the river Kolong, as it was the main channel. However, as soon as it turned into a dead channel, its water discharge has decreased gradually in time and at the present situation, its water flow is almost stagnant as both the ends are now being deposited by sediments and there has been growth of plants and trees. Thus, water of the both Dighaliati and Duboritoli are no longer carried to the Kolong instead, water of Duboritoli just flows into the Mora-Kolong and it eventually dries up with time.

Again, with the construction of the Salmara Pam road in 1989, the water of the Kolong was obstructed to enter into the village. This road does not allow the water of Kolong, which overflows its banks and enters the *Kherxona* and *Hatigeya beel* and then flows into the other parts of the village. The construction of this road thus acts as a barrier to the natural water flow into the village during the peak summer months. Thus, the blockade of flow causes serious harm lessening soil fertility, agricultural production and productivity and the biodiversity conditions of the wetland and other ecosystems as well.

Though pools have been fitted in the road, but these pools have been blocked over time and thus they no longer helps in regulating water flow on either side of the road. Thus, water of the southern part of Salmara Pam which earlier flows onto the Kolong, is now not flown onto it, except only when water level rises to a higher level and it overflows the road.

Besides, with the construction of four-lanes highway that forms the southern boundary of the village, many of the pools that have earlier been fitted in the road were removed and thus it has affected the hydrological environment in the village. Especially, if we have a look at the south-eastern part of the village where the four-lane highway passes through it has resulted in fragmentation of wetland ecosystem. Earlier, the water of the Mora-Kolong enters Dighaliati through a pool fitted in the NH-37 but after the construction of the four-lanes highway and removal of that pool in 2006, water of Kolong no longer flows into Dighaliati. It has resulted in the decrease of fish species in Dighaliati. Similarly, the water from the *chuburi* cannot flow onto the Mora-Kolong and thus output of water from Dighaliati is also obstructed.

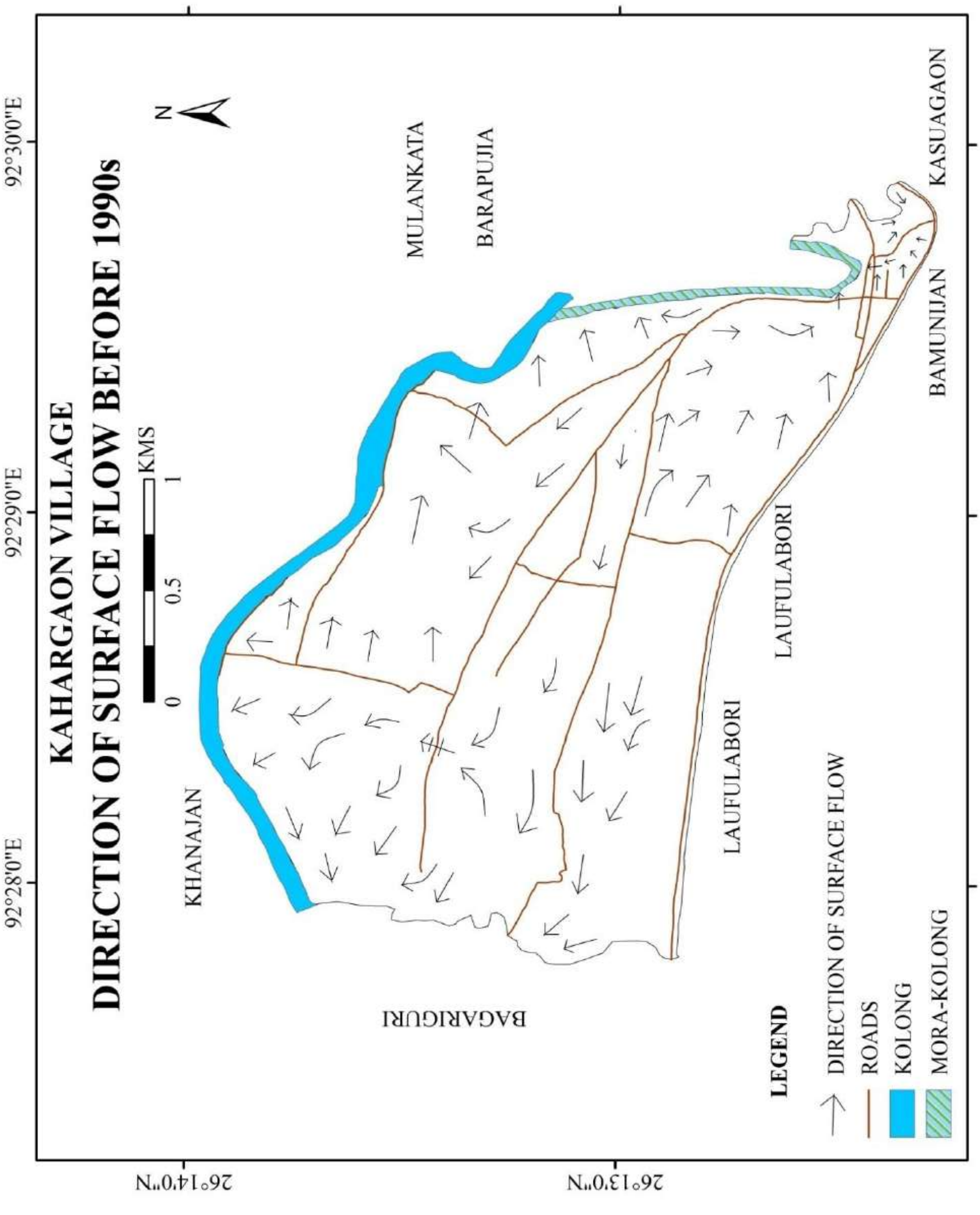


Fig. 4.1: Direction of surface water flow before 1990s

4.3 Changes in Wetland Hydrology

Like any other natural entities, wetlands are under growing pressure and threat due to rapid urbanization, industrialization and agricultural intensification, manifested by the shrinkage in their areal extent, and decline in the hydrological, economic and ecological functions they perform. (MEA, 2005; Bhagabati, 2012, Bassi et al., 2014). Alterations in such multi-dimensional aspects of wetlands have also been found in the villages of the Brahmaputra valley. The wetlands of the Kahargaon village have also undergone changes mostly in terms of their hydrological, morphological and ecological conditions mainly due to some irrational and unwise anthropogenic activities.

Table 4.2: Changes in water level of wetlands during summer

Types of wetlands	**Average water level of the wetlands during summer (in feet)**		**Change in water level (in feet)**	**Causes of change**
	Before 1970s	**In 2017-2018**		
Kolong	58.00	49.50	-8.50	Mainly due to rise in river bed.
Mora-Kolong	29.00	9.40	-19.60	Rise in river bed mainly due to siltation on its bed as water almost becomes static.
Pukhuris	5.20	8.62	3.42	Increase in depths so that water can retain in them and help the locals in rearing fish during the dry season; less interaction at present
Khals	6.50	4.90	-1.60	Dumping of household wastes.
Beels	5.50	3.30	-2.20	Flood frequency is less, only rain water is accumulated.

Source: Field Study, 2017-2018

The river Kolong discharges high volume of water before it was turned into a dead channel. Before 1970s, the average water level of the river was 58 feet in summer whereas at present, it decreased to 49 feet owing to the rise in riverbed caused by siltation. Because of excessive siltation and increasing human intervention, the bed of the Mora-Kolong has rose up resulting in a situation where the average water level stands at about 9.5 feet in summer.

Earlier, people used the water of the *khals* and *pukhuris* for drinking, cooking, washing clothes and utensils and several others. But after the 1970s, there has been a drastic decrease in the dependence of people on the wetlands. Thus, these wetlands are of not much important to the people except fishing and agriculture. People often use to throw garbage at the wetlands, mainly in the *khals.* Thus, the water level of the *khals* which earlier remained at average level of 6.5 feet decreased to 4.5 feet.

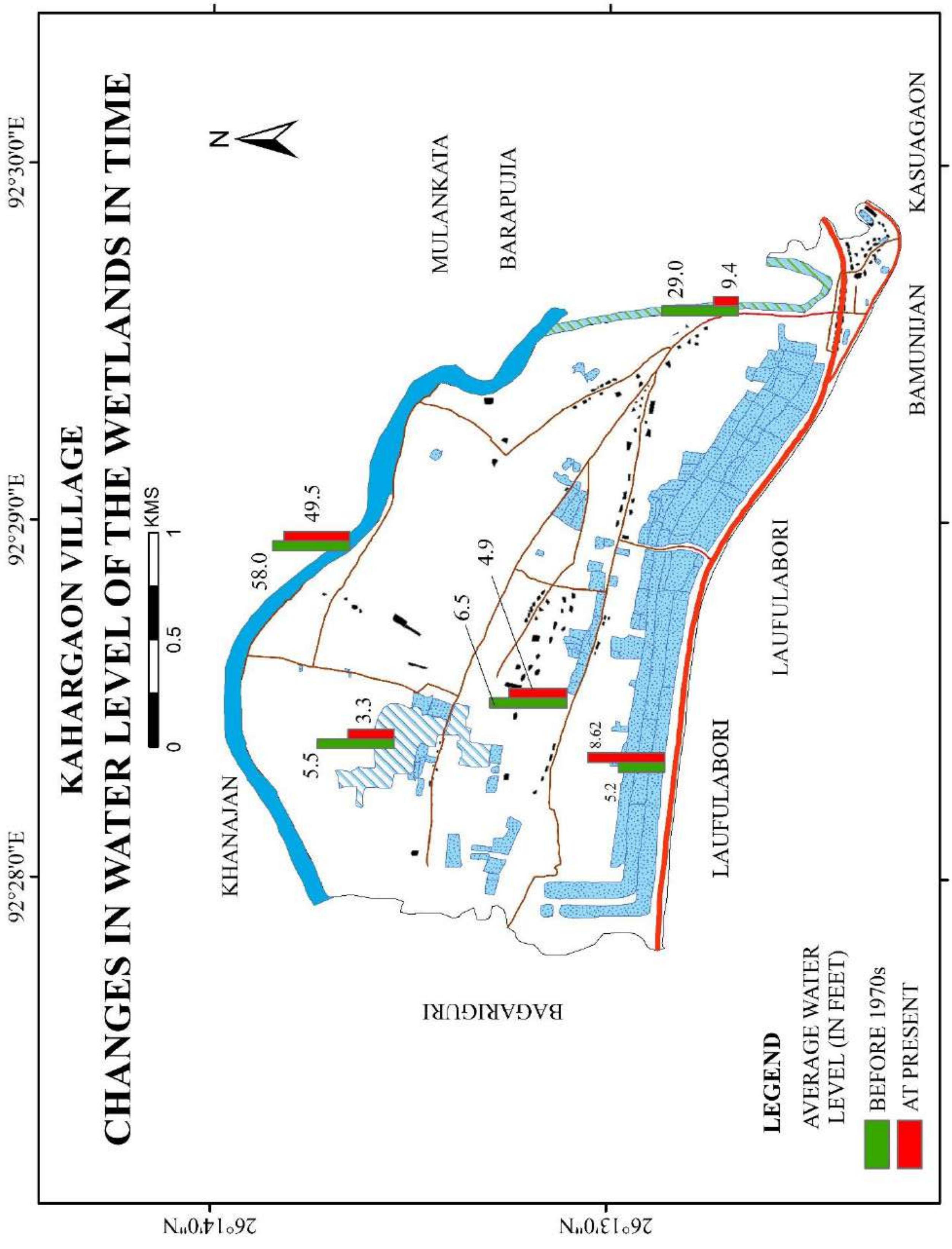


Fig. 4.2: Changes in water level of the wetlands in different times

On the other hand, the average depths of the *pukhuris* before 1970s were 5-6 feet which have increased to 6.3-7.5 feet in recent times. The villagers are now digging *pukhuris* with more depths with the help of backhoe diggers so that the water does not dry up in the dry seasons (February-March) and they can suitably practice pisciculture throughout the year. It is noteworthy that earlier, people used the water of the *pukhuris* for various purposes like fetching water, washing clothes, utensils, bathing, etc., especially in those, which are located adjacent to their houses. Moreover, it is found that the women of the households were mostly engaged in such activities and along with the women; children did not know how to swim. Therefore, to avoid any kind of mishap, the *pukhuris* were dug with fewer depths.

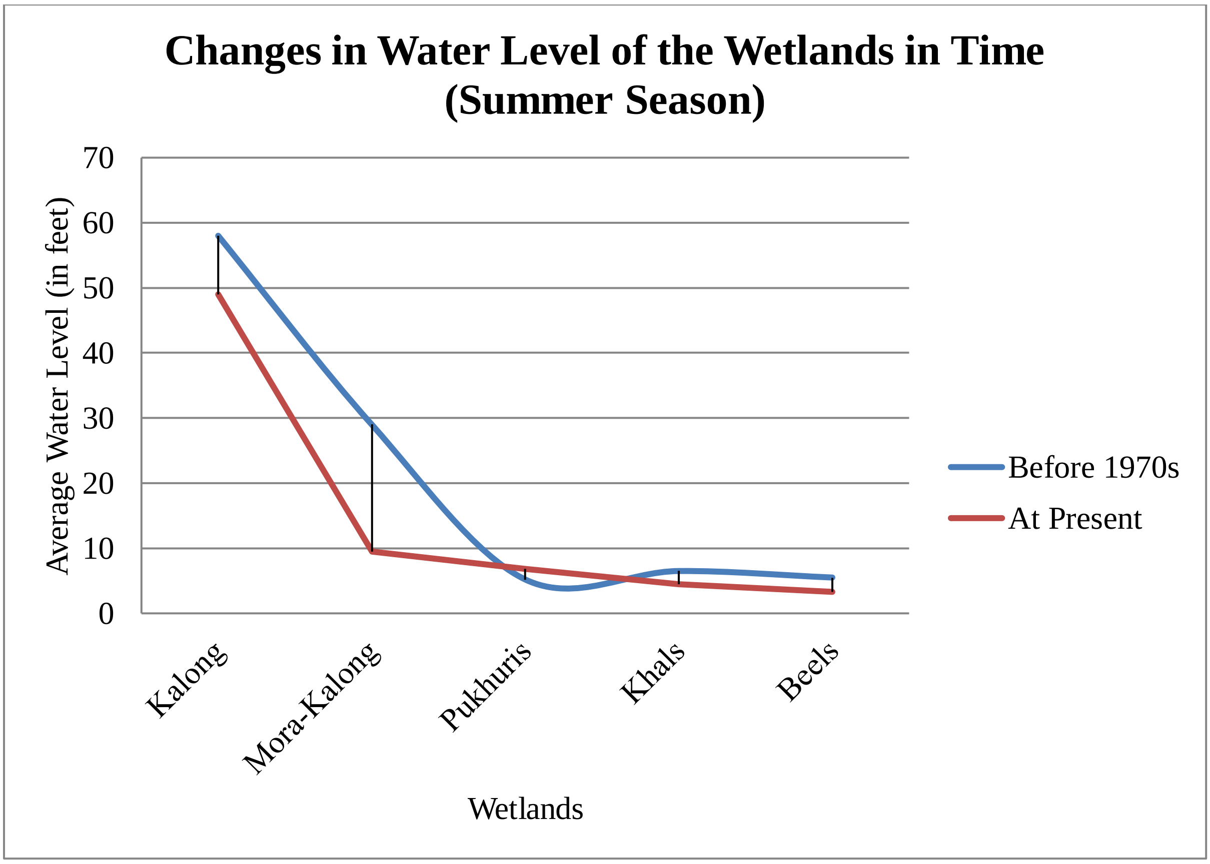


Fig. 4.3: Changes in water level of the wetlands in time

Apart from forming the northern boundary of the village, the Kolong once formed the eastern boundary before 1970s. The highly sinuous part of the river being very narrow caused frequent floods in the village resulting in loss and damage to crops, animals and humans and their property. As the local people complained about the river, causing frequent floods in the village, so the government in the early 1970s decided to join both the ends of the meander. The part of the Kolong, which is left out, is called Mora-Kolong and sometimes referred to as *morasuti*. Thus, the Kolong, *which earlier flowed forming both the eastern and northern* *boundary of the village,* is now only forming the northern boundary of the village. As both the meander ends are joined, the flow of the water increased comparatively while the discharge of the left out portion or Mora-Kolong went on becoming less with time.

It should also be mentioned here that there was a *hola* in Duboritoli *chuburi* of the village, which was turned into a *pukhuri* after further digging.

Fig. 4.4: A part of a *Hola*

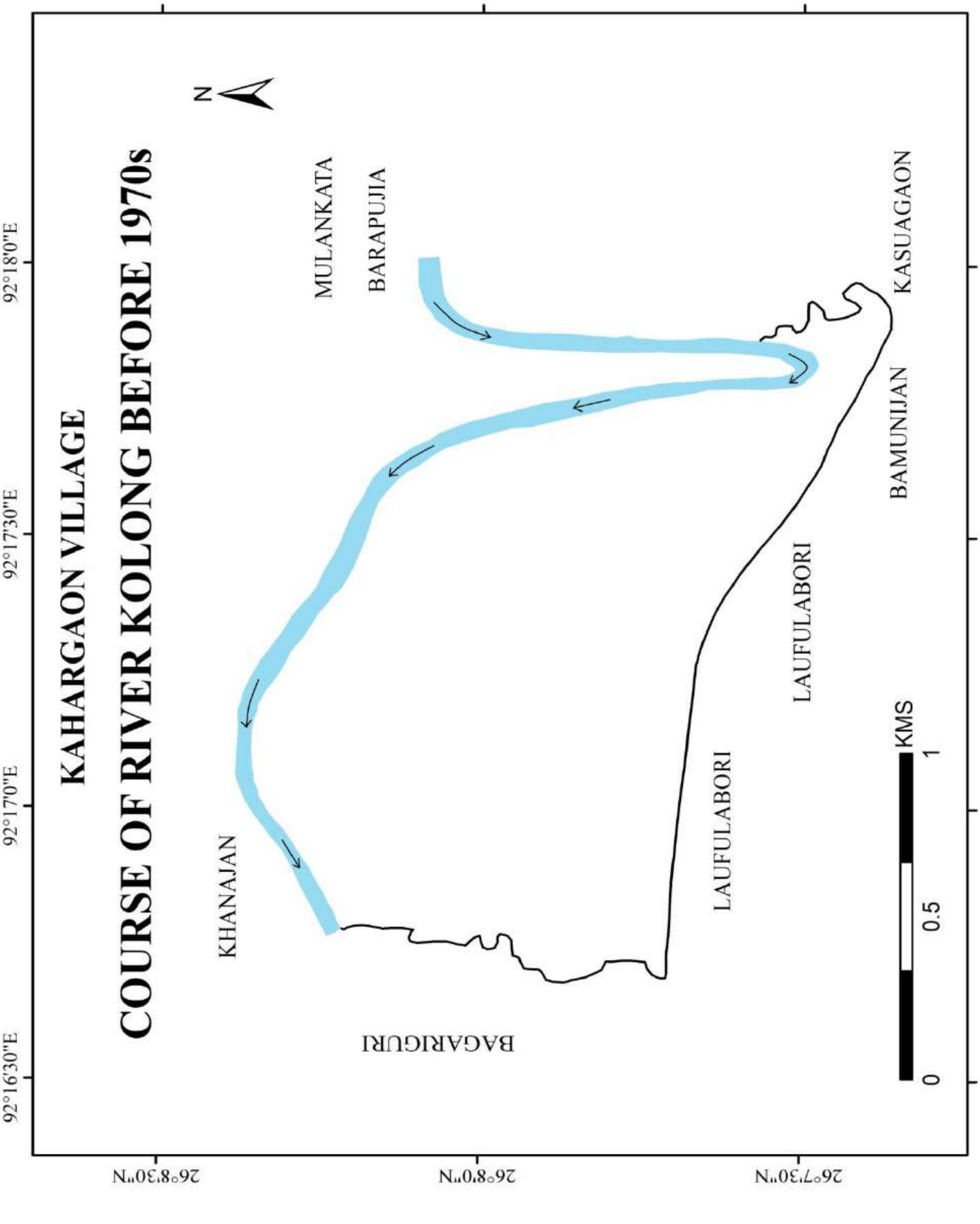


Fig. 4.5: Course of Kolong before 1970s

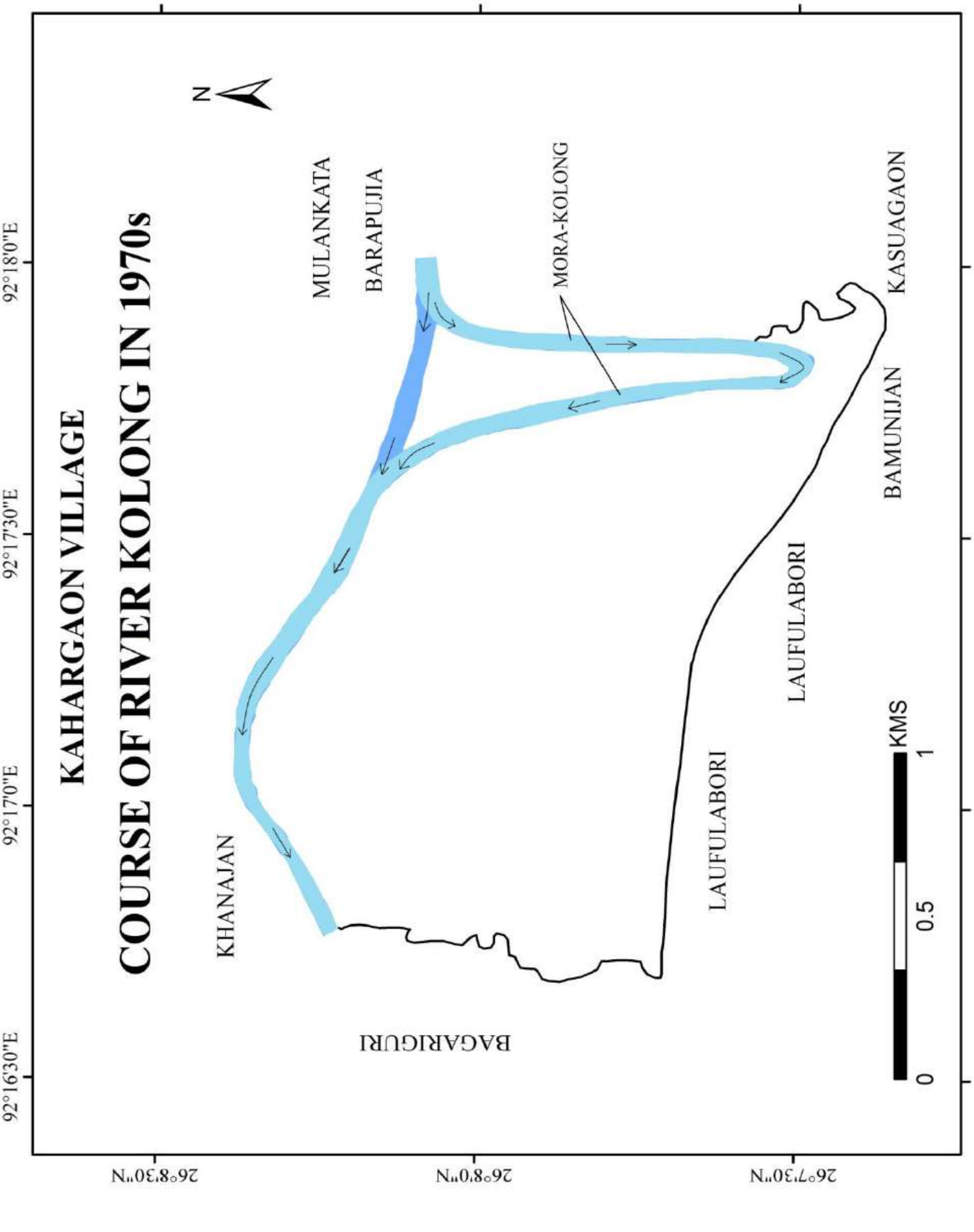


Fig. 4.6: Course of Kolong in 1970s

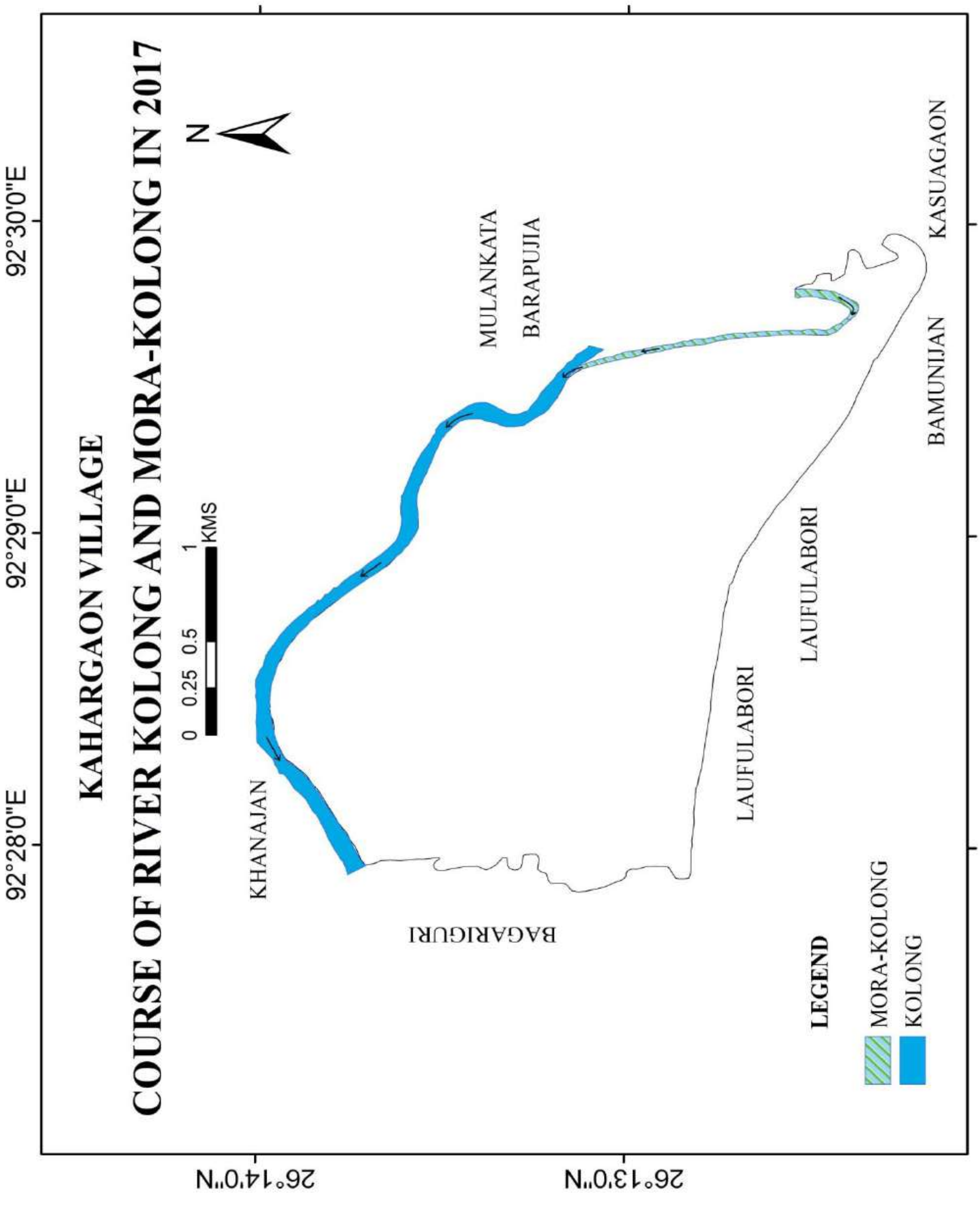


Fig. 4.7: Course of Kolong in 2017

4.3.1 Changes in Field Hydrology

With increasing human intervention, there have been drastic changes in field hydrology; especially there have been changes in the water level of the fields. Before 1990s, the water levels on the *Sali* fields were 1-2 feet on an average that has now decreased to 0.5-1 feet. The water level of the *bao* fields, which were 3-3.5 feet before 1990s, has now decreased to about 2 feet.

Table 4.3: Changes in water levels on autumn rice fields

Months	**Water level before 1990s (in feet)**	**Water level in 2017-18 (in feet)**
May	0.5	0.225 (6.8 cm)
June	0.9	0.62 (18.9 cm)
July	1.5	1.27 (38.7 cm)
August	1.0	0.81 (24.7 cm)
September	0.8	0.325 (10 cm)
October	0.7	0.325 (10 cm)
November	0.3	0.175 (5.3 cm)

Source: Oral interviews among the elderly people and field study, 2017-2018

Majority of the autumn rice fields are located are located in the northern part of the village in Kolongpar *chuburi*. The water level has decreased in *ahutolis* because the road of Kolongpar, *which acts as the embankment,* was raised in height due to which the water of Kolong cannot flow into the fields. As a result, the water level of the *ahutolis* has decreased by almost 0.5 feet on an average. However, the farmers still do not need irrigation for cultivating *ahu* rice.

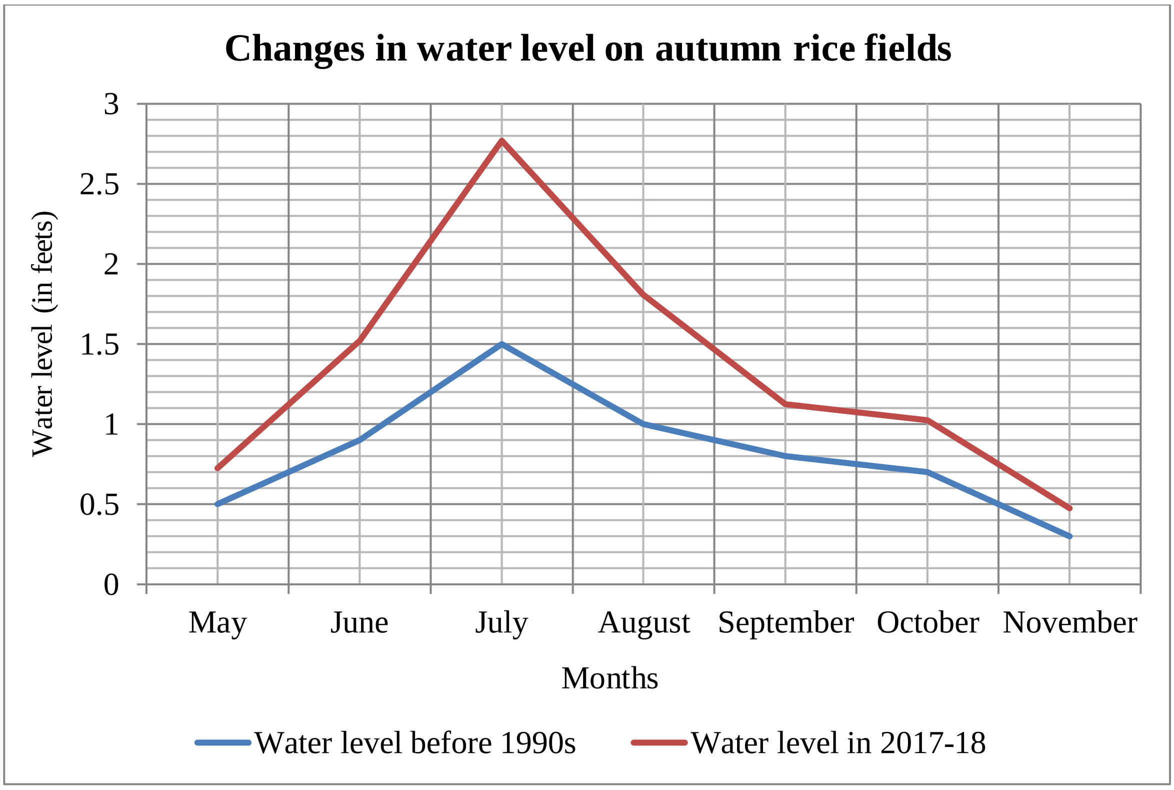


Fig. 4.8: Water level changes on autumn (*ahu*) rice fields

The *sali* rice fields are located in the central and the western part of the village which retain mainly the rain water for cultivating crops. Earlier, due to higher amount of rainfall and also flood water from the river led to higher water levels in the *salitolis* but due to lower flood frequency and decreasing amount of rainfall the water level in the fields has also decreased by almost 0.5 feet on an average.

Table 4.4: Changes in water levels on winter rice fields

Months	Water level before 1990s (in feet)	Water level in 2017-18 (in feet)
May	0.6	0.29 (8.76 cm)
June	1.5	0.94 (28.57 cm)
July	2.4	1.97 (59.80 cm)
August	1.8	1.40 (41.90 cm)
September	1.3	0.60 (17.53 cm)
October	0.8	0.49 (14.86 cm)
November	0.3	0.06 (1.9 cm)

Source: Oral interviews among the elderly people and field Study, 2017-2018

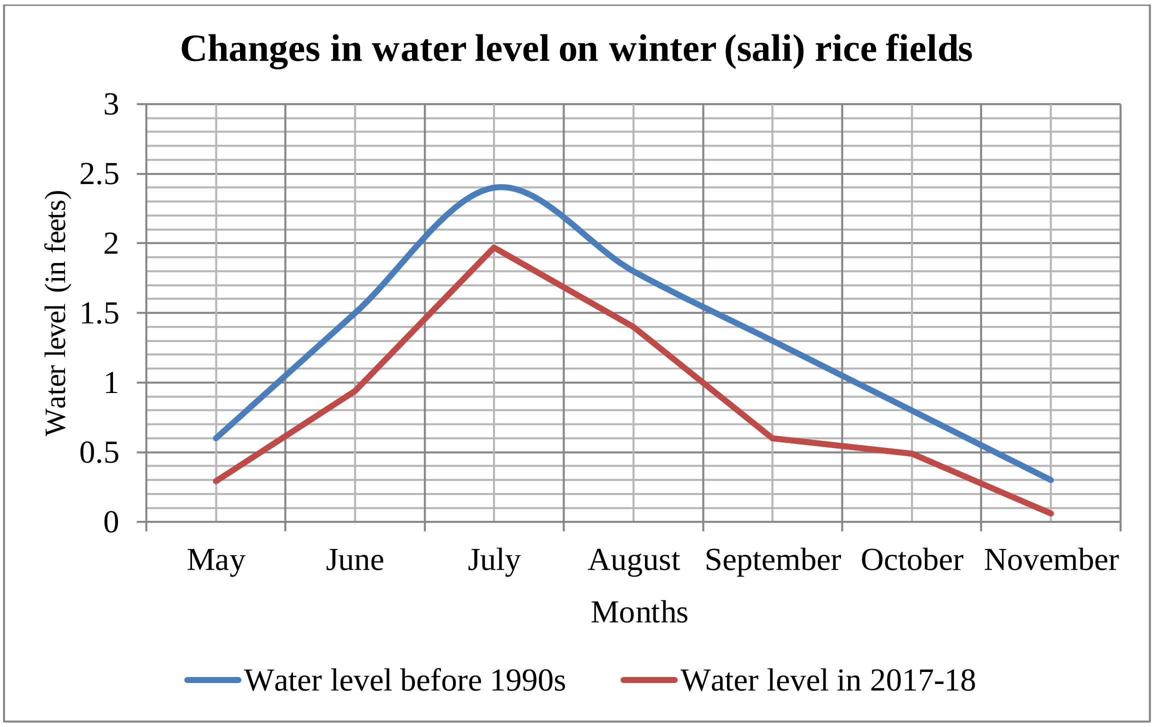


Fig. 4.9: Water level changes on winter (*sali*) rice fields

On the other hand, the *baotolis* are located in three *chuburis,* viz. Salmara Pam, Garhmaj and Duboritoli. In Salmara Pam, *bao* rice is cultivated in the southern part of the *beel* because the water level on the *beel* has decreased by 2.2 feet to as low as 3.3 feet creating congenial conditions for cultivating *bao* rice. However, the water levels on the other two major *baotolis* have also decreased much due to which the production has gone lower than before. The water levels on the *baotolis* have decreased by almost 1 foot on an average.

Table 4.5: Changes in water levels on *bao* rice fields

Months	Water level before 1990s (in feet)	Water level in 2017-18 (in feet)
May	2.5	2.0 (60.96 cm)
June	3.1	2.2 (67.05 cm)
July	3.5	2.8 (85.34 cm)
August	3.8	2.5 (76.2 cm)
September	3.3	2.2 (67.05 cm)

October	2.8	2.1 (64.0 cm)
November	2.3	1.8 (54.86 cm)

Source: Oral interviews among the elderly people and field Study, 2017-2018

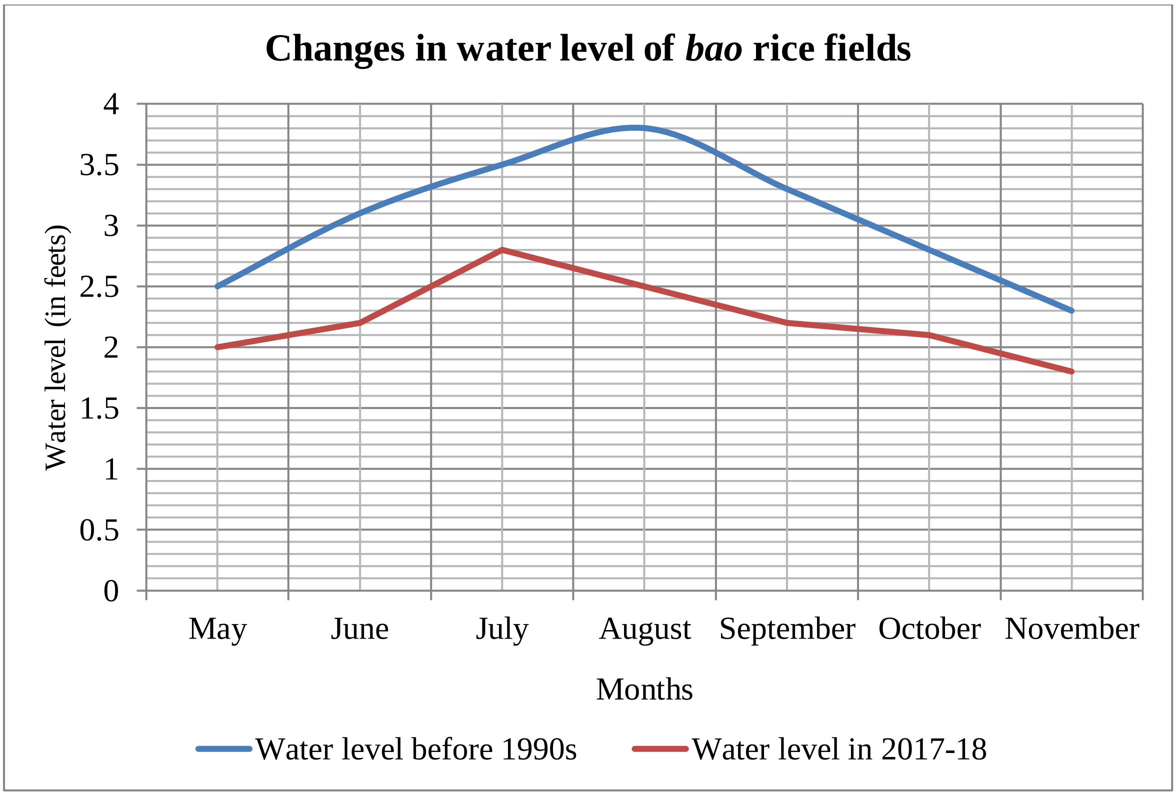


Fig. 4.10: Water level changes on *bao* rice fields

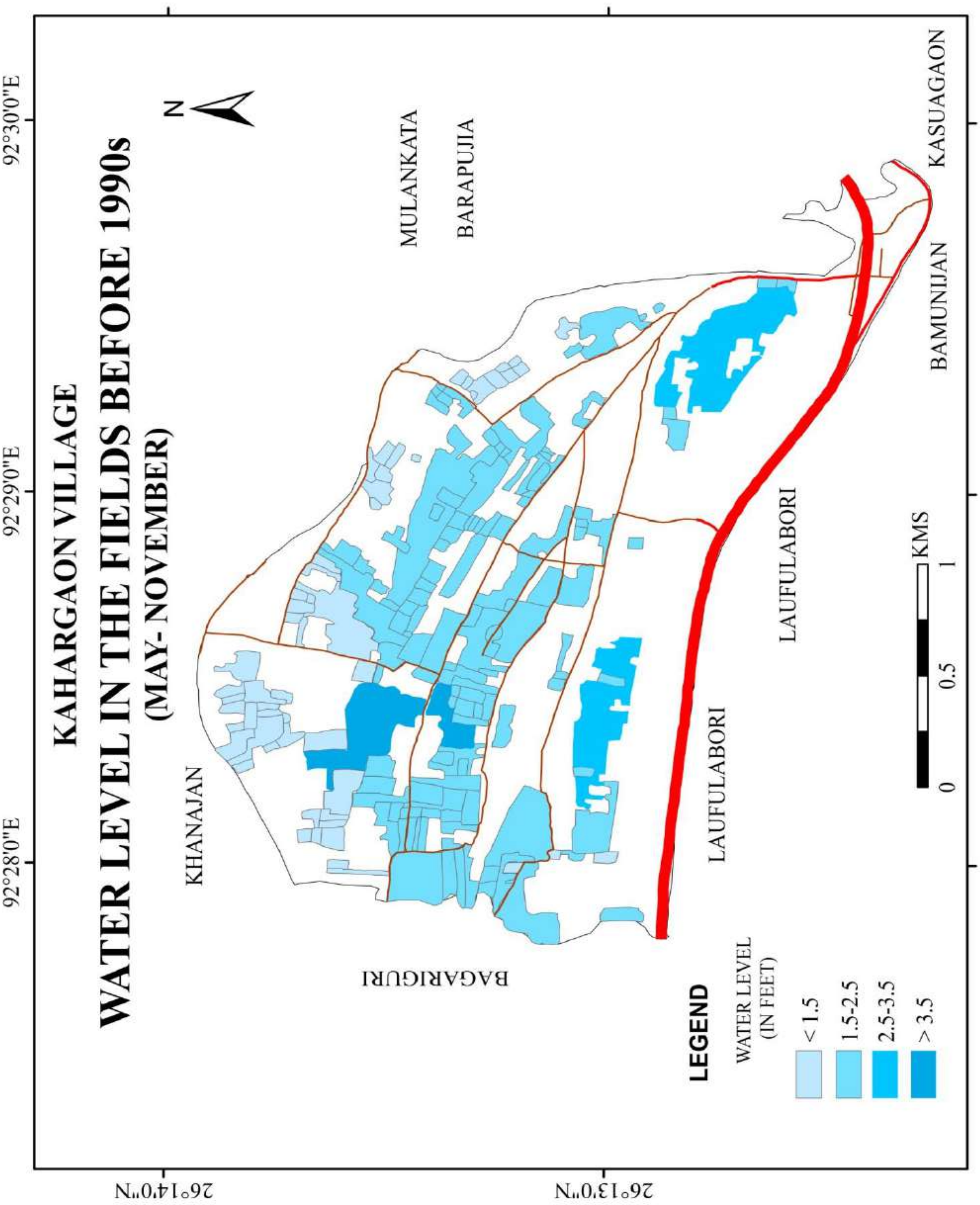


Fig. 4.11: Water level on the agricultural fields before 1990s

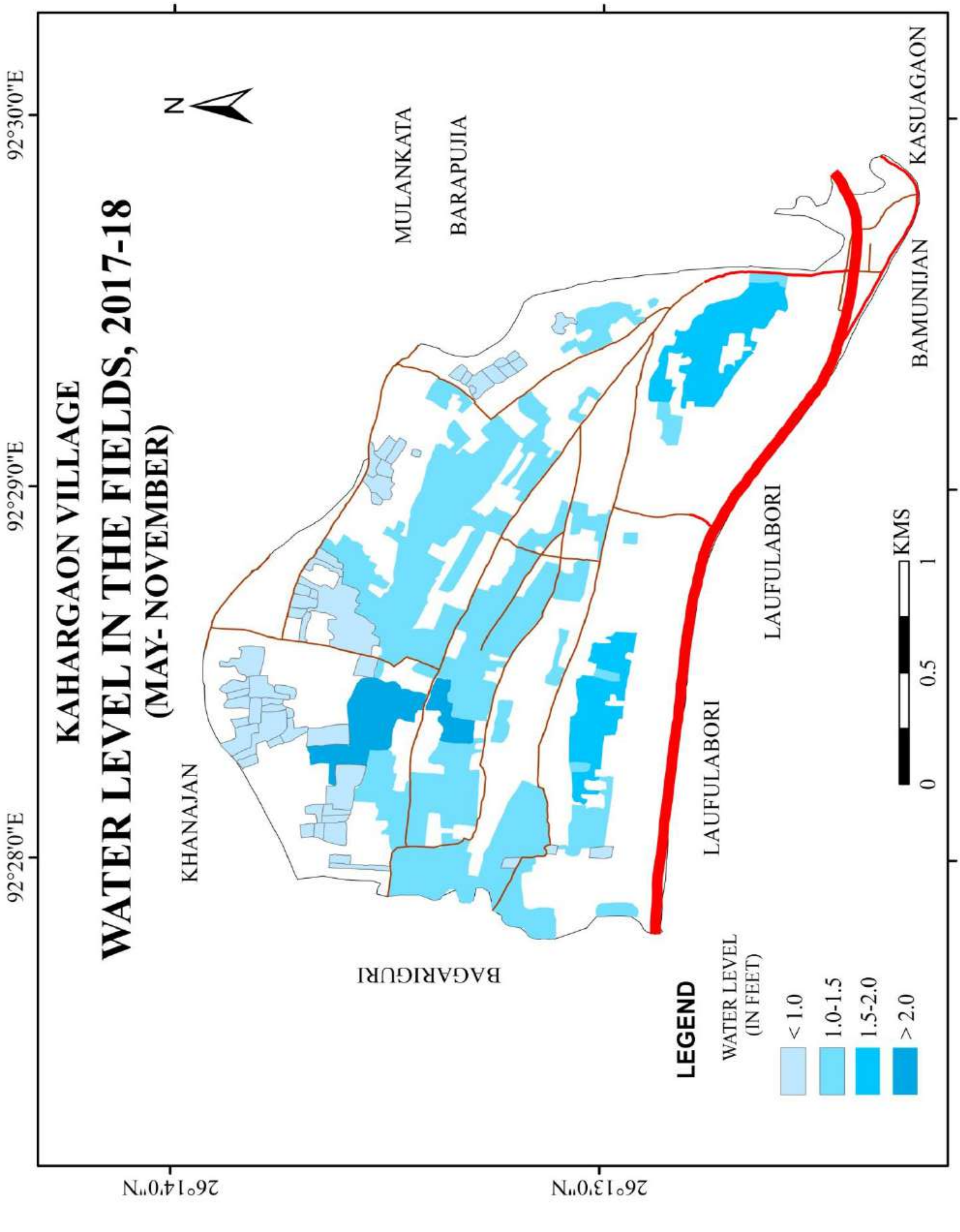


Fig. 4.12: Water level on the agricultural fields during 2017-18

4.3.2 Changes in Water Use and Land Covered by Water

Changes in Water Use

The uses of water in the village have been changing over time (Table 4.6). It is noteworthy that earlier, before the introduction of tube/ring wells, people had to collect water from the natural wetlands, which were far away from their home. The women folk had to walk for a considerably long distance to procure water. Therefore, they were compelled to use water optimally for their household requirements. Again, in the early times, as the natural wetlands were the only sources of water for drinking, bathing and washing purposes, so they did not cause harm to these wetlands by disposing wastes and pollutants. The water, available in different wetlands was used for supplying them onto agricultural fields, for bathing humans and domesticated animals, washing clothes and utensils, soaking seeds, jute plants and some building materials to name a few. Therefore, the availability of water in the rivers and wetlands was the most important and the matter of concern for the rural people. It is interesting to note that earlier, people washed some of their heavy clothes like bed sheet, warm clothes, mosquito net etc only during some occasions, like Bihu, Puja, *Saat*, etc. However, with the growing health consciousness and the availability of water at their own homes from tube wells, ring wells and electric motor pumps, people now wash their clothes regularly. Earlier, people washed their clothes in Kolong, Mora-Kolong, *pukhuri*, *khal*, etc. but gradually people started washing their clothes using the water from tube wells, ring wells and electric motor pumps. Thus, the per capita water consumption is much more now than before, especially before 1970s.

The changes in water use by the people of the village can be understood easily when divided into the following five phases on the basis of different temporal scales.

1) Before 1950s: Before 1950s, people of Kolongpar, Duboritoli and Dighaliati *chuburi* is mostly used water of the river Kolong for various purposes, like drinking, bathing, washing clothes, washing utensils, agriculture, drinking water for cattles, soaking of seeds, etc. It is because of the fact that all these *chuburis* are located adjacent to the river Kolong. While, Garhmaj is located away from the river Kolong and thus people do not use the water of the river in these *chuburis*. On the other hand, the people in Garhmaj mostly use the water of *pukhuris and khals* for their daily use. It is however, important to mention that there was no human settlement in the area what is presently known as Salmara Pam.

2) 1950-1970: Noteworthy that, with the installation of the first tube well in 1952 at Dighaliati *chuburi*, many people procured water from that tube well. People were in long queue to avail water from it. Only few households who lived by the side of the river Kolong used its water for drinking purposes. Again, with the first ring well in the early 1960s, it helped the villagers to avail water without going to the river or *pukhuris* or *khals.* Therefore, except for drinking water for cattles and soaking of seeds, people did not use water from the *pukhuris* and *khals* as they have easy access to drinking water and people also do not have to carry the water pots for long distance.

However, the Kolong remained as the main source of water for the people of both Kolongpar and Duboritoli *chuburis*. But, at present, the dependence of the people on the *pukhuris* and *khals* has reduced considerably. It is important to mention that the first tube wells at Duboritoli and Garhmaj were installed in 1965 and 1969 respectively. As a result of the installation of tube wells in Garhmaj, people's dependence on *khals* and *pukhuris* started declining drastically. On the other hand, the people in Salmara Pam mostly used water from the *beels* (*Kherxona* and *Hatigeya*), *khals* and *pukhuris.*

3) 1970-1990: This phase bears great significance as Mora-Kolong was artificially created by joining the two-meander ends of river the Kolong. Thus, few people of Duboritoli and Dighaliati used water of Mora-Kolong as these two *chuburis* are located on its banks.

The first tube well in Salmara Pam was installed in this phase and as a consequence, people stopped using the water of the *beels* and *khals.* It is noteworthy that *pukhuris* in *Salmara Pam* were first dug in this phase and people used its water for almost every chore of theirs.

Interestingly, the river Kolong still continued to dominate the water use source of the people in Kolongpar but with the installation of the first ring well, a few households went on to depend on it. While, with the installation of ring wells in Duboritoli, water use of many households were then confined to those ring wells.

4) 1990-2010: The first tube well at Kolongpar was installed in 1992 and thereafter, many tube wells have been installed in the *chuburi.* Consequently, the use of water of the *pukhuris*, *khals* and even Kolong has drastically reduced. Instead, the number of households started fetching water from the *tube* wells. Even a diesel motor pump was installed in the agricultural field, the water of which was used by three (3) households to cultivate rice, mainly *boro* variety.

Similarly, except Salmara Pam, most of the households in other *chuburis* viz. Duboritoli, Garhmaj and Dighaliati were no longer much dependent on the river Kolong, Mora-Kolong, *pukhuris* and *khals.* Unlike Kolongpar, people used water of the tube wells and ring wells. Further, people have installed electric motor pumps (EMPs) in their houses and diesel motor pumps (DWPs) in agricultural fields due to which the dependence of people on wetlands for water resources has rapidly declined. But, it is important to note that as Dighaliati does not have any agricultural lands, therefore no water is used in this sector from any source whether natural or man-made.

5) 2010-2017: The numbers of tube wells, ring wells and EMPs have increased in this phase in all the *chuburis.* In Kolongpar, people now use water of the tube wells, ring wells and EMPs for various purposes but sometimes, some people wash their clothes in Kolong on some special occasions like Bihu. Very few people in Duboritoli also use water of Kolong for drinking, bathing and other allied activities.

Thus, except for agricultural use, the people in all the chuburis no longer use drinking water for cattle and soaking of seeds, water of the wetlands. People in the village have the perception that water of the tube wells and EMPs are much pure and safe than the water of the wetlands.

In Dighaliati, water of the wetlands is not even used as drinking water for cattles, instead, people provide water of the tube wells and EMPs to the cattle. The ring wells in this *chuburi* are also either broken or filled up as there is no usage of water from them.

It is thus, very important to note that before 1970s, the extraction and utilization of the ground water resources was very limited and thus the ground water table was very rich.

Again, fishing was another activity that was carried out in the wetlands. In *pukhuris*, people rear or domesticate fishes for their own consumption and also for selling, a part of which generates income for them. Similarly, the water of the *khals* provide congenial conditions for the sustenance of wild fishes like *goroi*, *magur*, *sol*, *kawoi*, *sengeli*, etc. Similarly, the people of all the chuburis, especially Kolongpar, Duboritoli and Dighaliati, also carried out fishing in Kolong and Mora-Kolong.

Table 4.6: Water use and their changes over time

Purpose of water use	Before 1970s	1970 – 1985	1985 – 2000	2000 – 2017
	K= River Kolong ***MS***= *Morasuti* (Dead Channel) ***P***= *Pukhuri* (Pond) ***Kh***= *Khal* (Natural Pond)	***K***= River Kolong ***MS***= *Morasuti* (Dead Channel) ***P***= *Pukhuri* (Pond) ***Kh***= *Khal* (Natural Pond) **TW**= Tube Well **RW**= Ring Well	***K***= River Kolong ***MS***= *Morasuti* (Dead Channel) ***P***= *Pukhuri* (Pond) ***Kh***= *Khal* (Natural Pond) **TW**= Tube Well **RW**= Ring Well	***K***= River Kolong ***MS***= *Morasuti* (Dead Channel) ***P***= *Pukhuri* (Pond) ***Kh***= *Khal* (Natural Pond) **TW**= Tube Well **RW**= Ring Well **EMP**= Electric Motor Pumps **DWP**= Diesel Water Pumps
Drinking	K,MS *P, Kh*	RW, TW, *P, Kh, MS, K*	TW, RW, *MS, K*	EMP & TW
Bathing	MS, *P*, K, *Kh*	*P, MS, RW, K, TW*	TW, RW, *P, MS, K*	EMP & TW
Washing clothes	*P*, MS, K, *Kh*	*P, MS,* RW, TW, *K*	TW, RW, *MS, K, P*	EMP, TW, *MS, K*
Washing utensils	*P, Kh,* MS, K	RW, *P, Kh, TW, MS, K*	TW, RW, *P, MS, K*	EMP, TW
Agriculture	*Kh, P, MS,K*	*Kh, P, MS,K*	TW, *Kh, P, MS, K*	DWP, TW &*Kh*
Drinking Water for cattles	*P, Kh, MS, K*	*P, Kh, MS, K, RW*	TW, RW, *P, K, MS, K*	TW, *P, Kh* &EMP
Soaking	*Kh, P, MS*	*Kh, P, MS*	*P, K, MS*	*P, K, MS*

Source: Field Survey, 2017-2018; Note: The codes used in the Table indicate the sources of water and the pattern of ordering of the codes reflects the preference level of water use.

It is important to note that, it was only after the independence of the country that tube wells has been installed for the very first time in the village. However, the number of tube wells in the village has been gradually increasing after the 1960s. Again, with the installation of the first ring well in the 1960s, it has also been increasing thereafter. The ring wells are very less in number and are mostly public. It should also be mentioned that most of the ring wells have been filled up over time as because the preference was given mostly to the tube wells for collecting water.

In the first decade of the 21st century, some villagers have used a number of electric motor pumps (EMPs), and in the next decade, it increased to 11 in number.

Table 4.7: Trend of installation of water sources in Kahargaon, 1940-2017

Years	Total no. of tube wells	No. of tube wells installed	Total no. of ring wells	No. of ring wells installed	Total no. of EMPs	No. of EMPs installed
1940-1950	0	0	0	0	0	0
1950-1960	1	1	0	0	0	0
1960-1970	5	4	1	1	0	0
1970-1980	11	6	3	2	0	0
1980-1990	22	11	8	4	0	0
1990-2000	57	35	9	1	0	0
2000-2010	140	83	9	0	10	10
2010-2017	184	44	10	1	31	21

Source: Field Study, 2017-2018

The first tube well in Kolongpar was installed only in the early 1990s because until then Kolong remained as the only source of drinking water. Thereafter, 5 other tube wells have been installed in that decade followed by 13 in the next decade i.e. the first decade of the 20th century resulting in a total of 19 tube wells in the village.

It should be noted here that earlier, people of each of the *chuburis* were dependent on the wetlands for water sources to use them in different purposes. However, the nature of interaction with the wetlands changes with the purposes of water use. Thus, the nature of use of wetlands for various purposes like drinking water for both men and animals, bathing, washing clothes and utensils, agriculture, soaking of crop saplings, etc. is different. Before 1950s, Kolong was the main source of water for the people but it gradually changed with time and now tube wells is the major source of water followed by EMPs (Appendix 2).

Land Covered by Water

It is interesting to note that many parts of the village Kahargaon are covered by water in the forms of wetlands of different types and sizes, low laying fields and river and dead channel. However, the area of land covered by water has also been changing over time, especially after 2000s with the rapid degradation of the village wetlands in the name of some so-called developmental activities on the one hand and the increasing expansion of human settlements on the other. From the later parts of the 20th century, the number of wetlands, especially the *khals* have been gradually decreasing as many of the new settlements have grown up by filling the *khals* while some others have converted them into *pukhuris* by further digging and managing their banks.

Table 4.8: Trend of increase in *pukhuris*

Years	Number of *pukhuris*	Number of households possessing *pukhuris*	% change
Before 1960	0	0	-
1960-70	22	1	-
1970-80	24	4	+ 9.09
1980-90	13	3	-95.83
1990-00	14	10	+ 7.69
2000-10	35	20	+150.0
After 2010	12	27	-65.71

Source: Field Survey, 2017-18

On the other hand, the land needed to fill those *khals* over which the road has been built was dug from the agricultural fields thereby increasing the number of *pukhuris* and sometimes the then existed *pukhuris* were also dug too much depth so that the *pukhuris* can retain water for long which will help the owners in practicing pisciculture. It is noteworthy that in the last decade i.e. 2000-10, there has been an increase in the number of *pukhuris* by 150%.

Table 4.9: Land covered by *pukhuris* and *khals*

Years	Total land covered by *pukhuris* (in ha)	Decadal change in land covered by *pukhuris*
Before 1960	0	-
1960-70	2.6	-
1970-80	4.8	+ 84.62
1980-90	5.71	+ 18.96
1990-00	8.1	+ 41.86
2000-10	15.8	+ 95.06
After 2010	11.2	-29.11

Source: Field Survey, 2017-2018

The total area covered by the *pukhuris* was approximately 16.32 hectares in 1990, which has been increased to about 48.21 hectares in 2017. The number of the *pukhuris*, which was only 59 in 1990, has doubled in 2017. While, the number of *khals* has decreased from 137 in 1990 to 85 in 2017. In terms of area, the total area covered by *khals* has decreased from 5.40 hectares in 1990 to 3.01 hectares in 2017. Thus, the land covered by water has changed over the years because of increasing human pressure on the wetlands as well unwise developmental activities.

Table 4.10: Changes in number and area of natural and man-made ponds

Type of wetlands	Number			Area (in ha.)		
	1990	2017	Change in %	1990	2017	Change in %
***Pukhuri* (Man-made pond)**	59	120	+103.39	16.32	48.21	+195.40
***Khal* (Natural Ponds)**	137	85	-37.96	5.40	3.01	-44.25

Source: Field Study, 2017-2018.

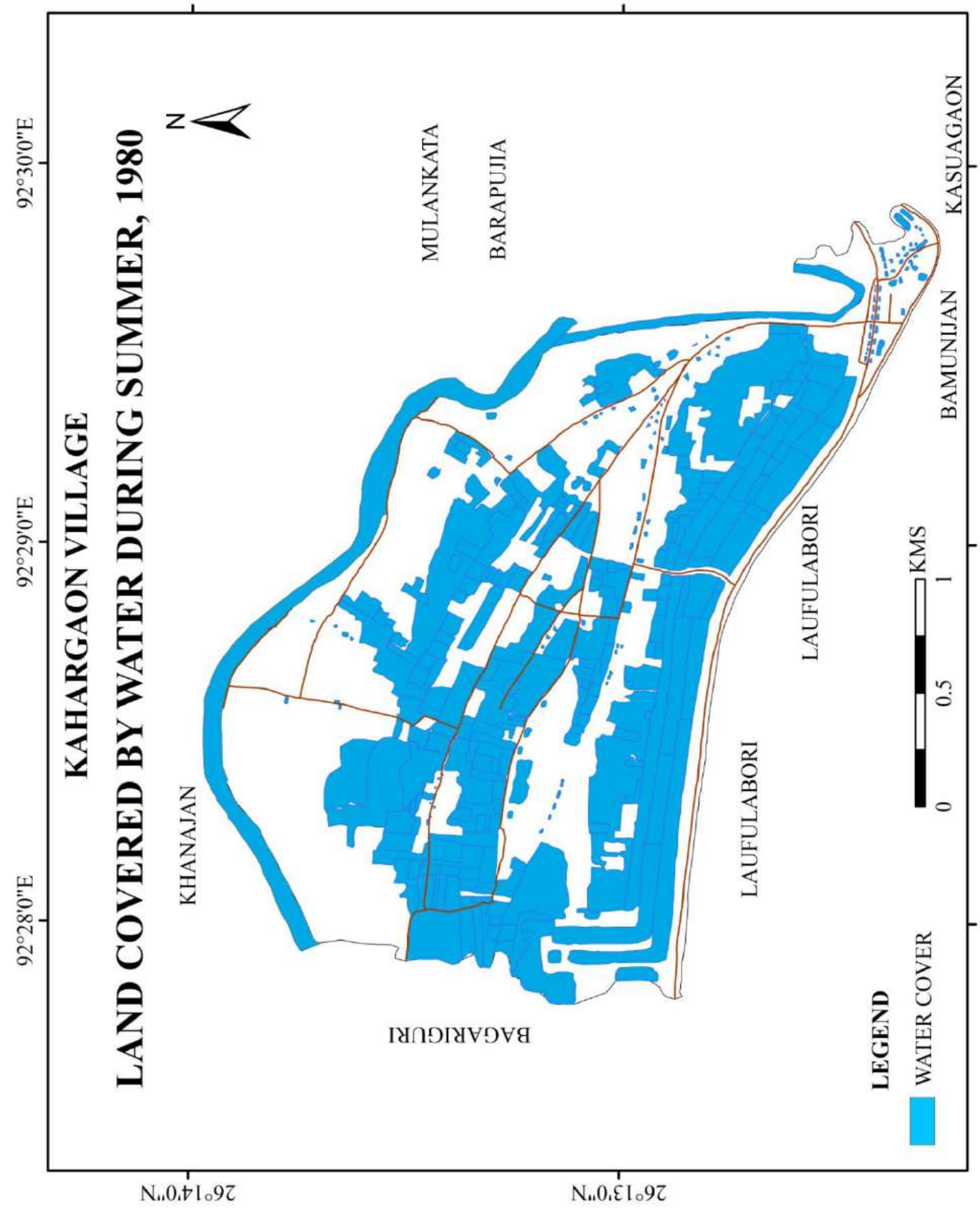


Fig. 4.13: Land covered by water during summer, 1980

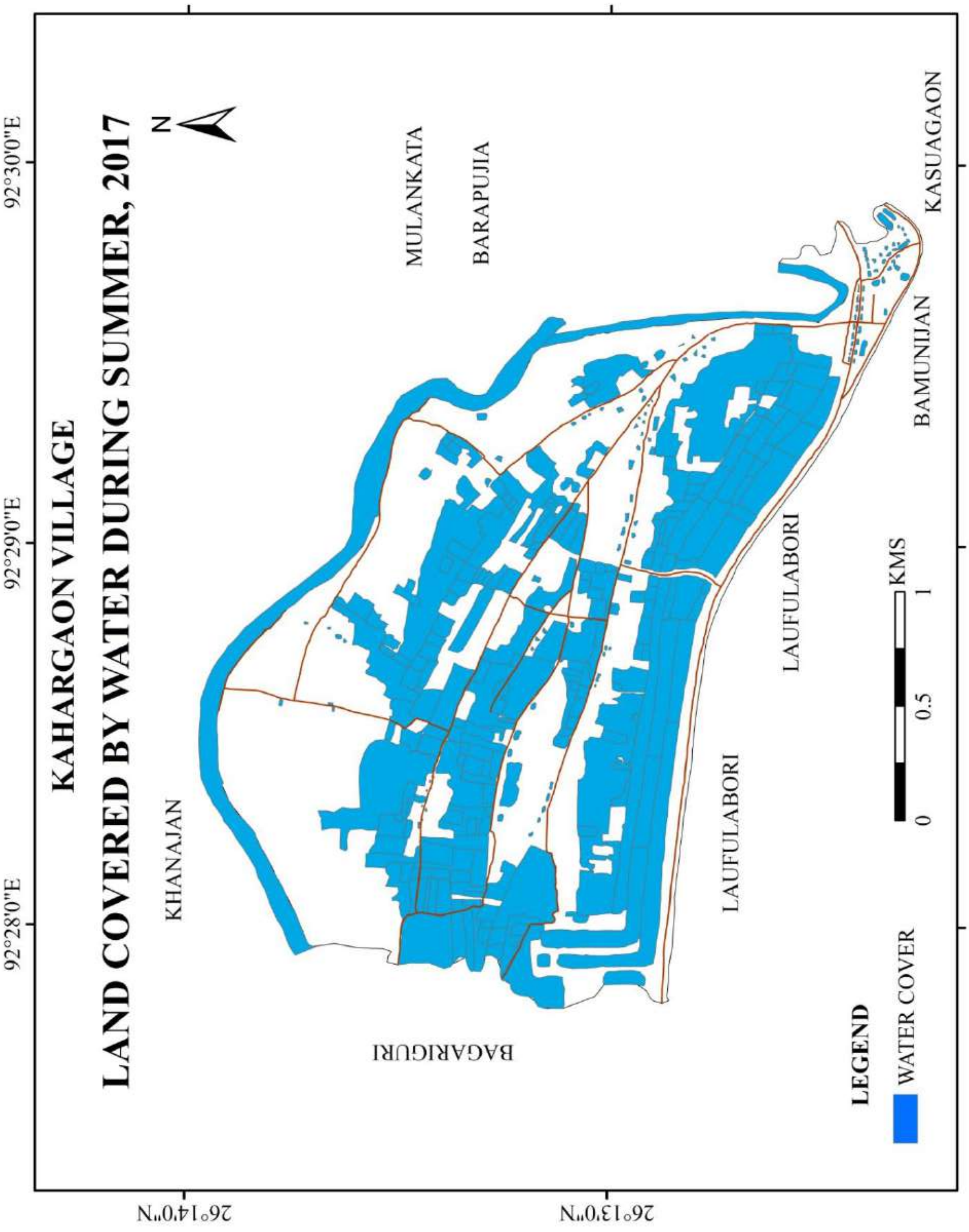


Fig. 4.14: Land covered by water during summer, 2017

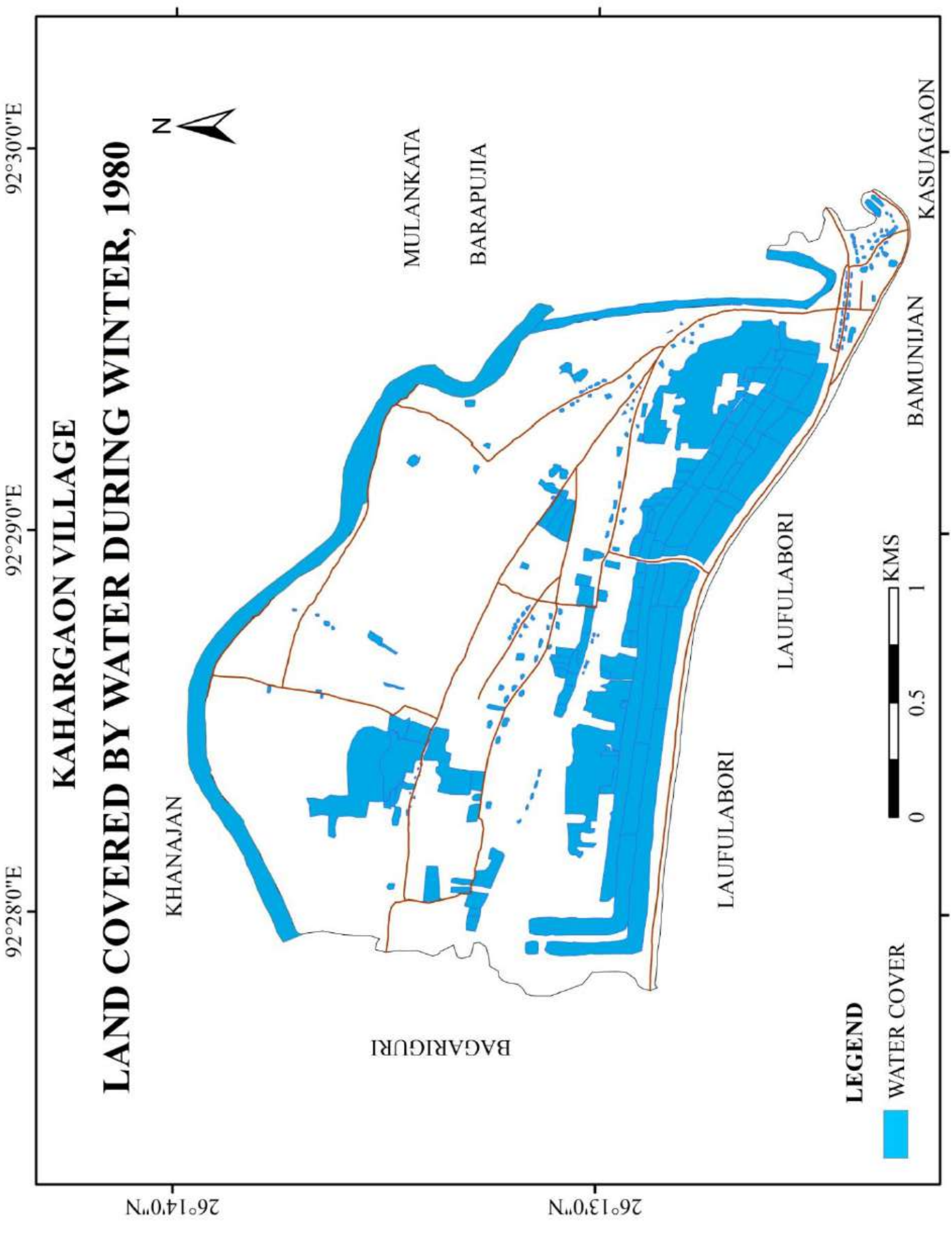


Fig. 4.15: Land covered by water during winter, 1980

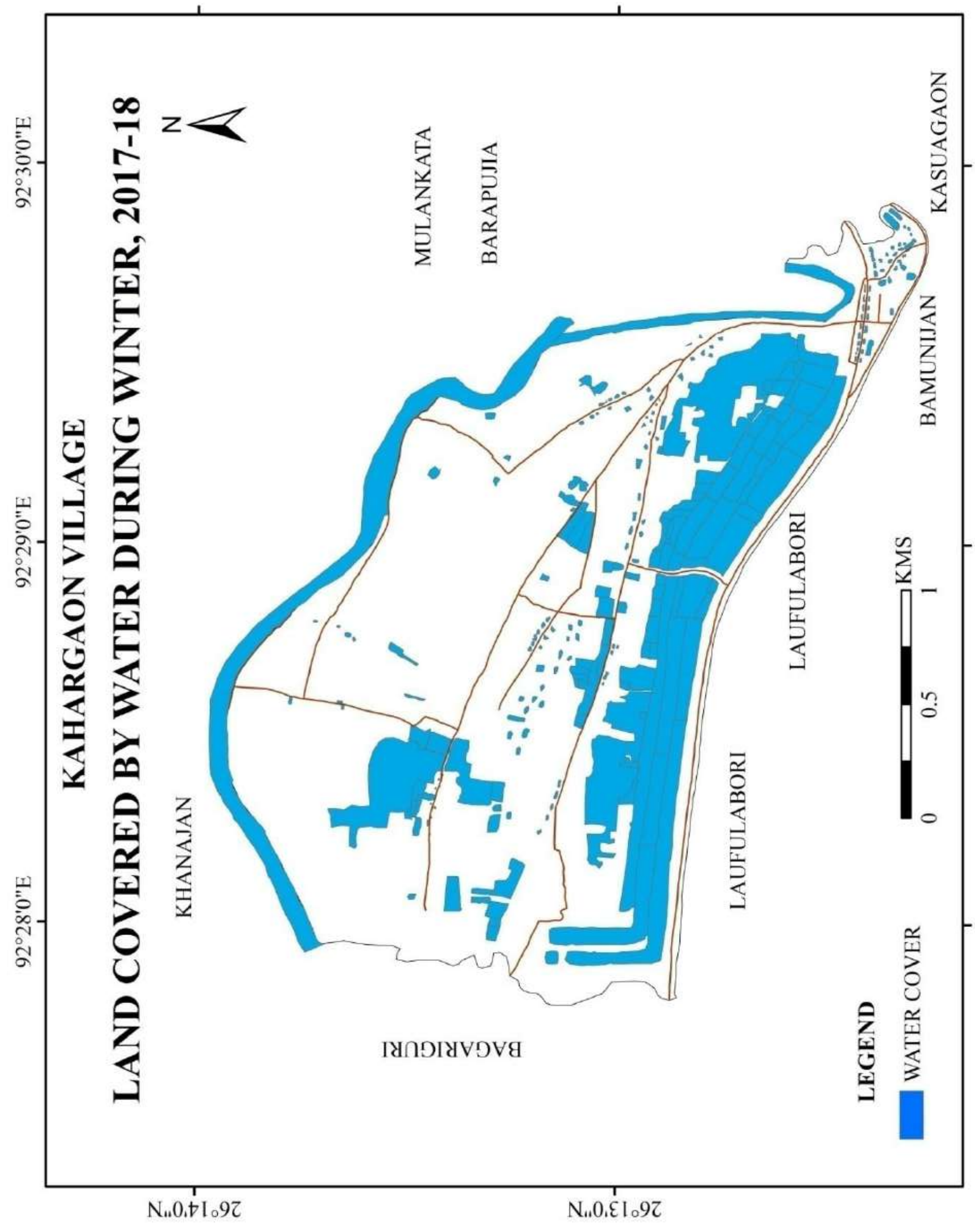


Fig. 4.16: Land covered by water during winter, 2017-18

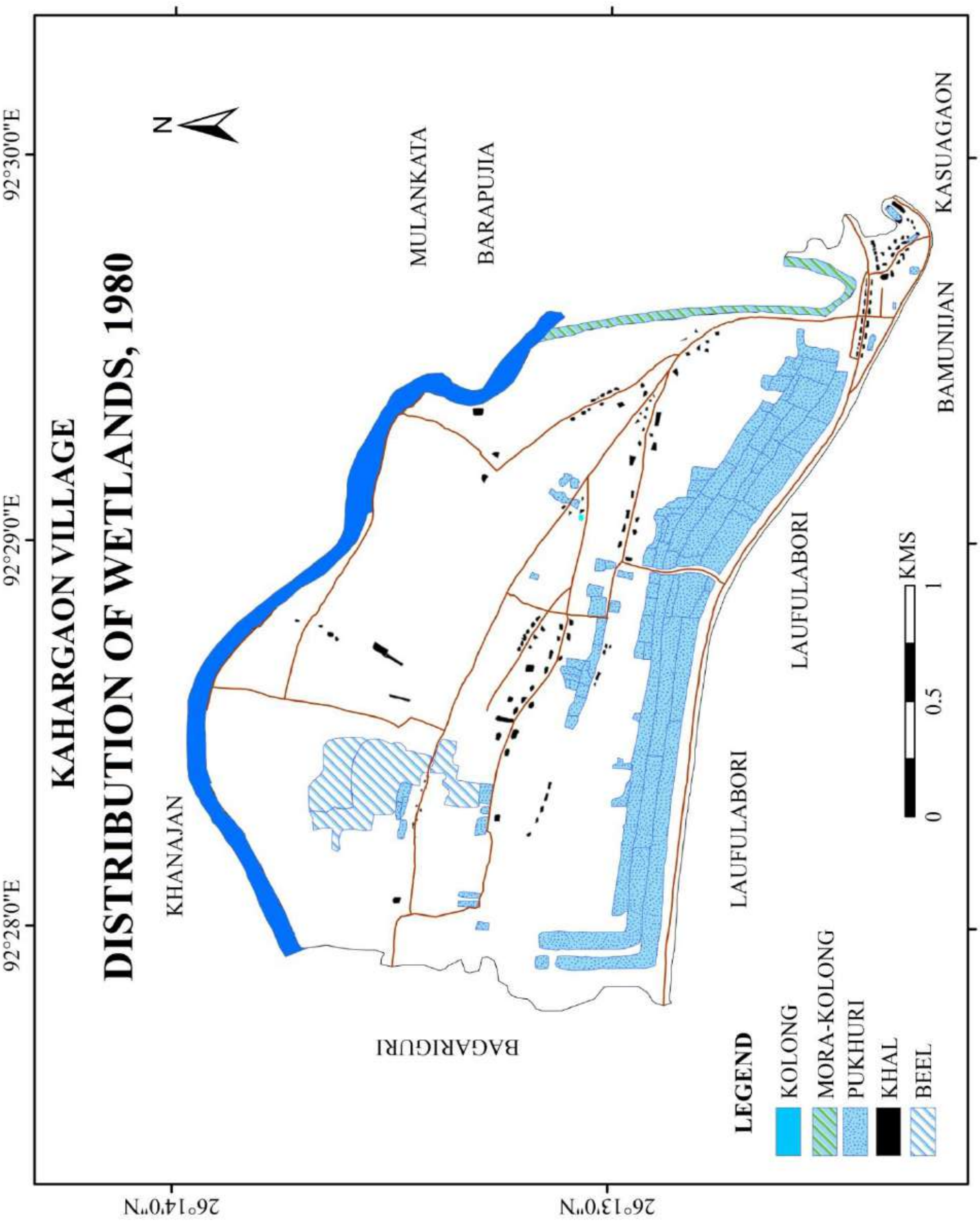


Fig. 4.17: Distribution of wetlands, 1980

4.3.3 Changes in Aquatic Ecosystem

The hydrological conditions that existed in the village set a balance of its ecological settings wherein there existed abundance of species of plants and animals including aquatic ones. The hydrological conditions that prevailed earlier experienced free flow of water and all the components of the village's ecosystem were in perfect harmony as there were no human interventions. But with the growing expansion of human settlements since 1826, its ecological settings were being disturbed. However, the pace of intervention was not that intense earlier but it became serious especially after the 1970s when people started degrading the nature more.

Many culverts on internal village roads that existed before were lifted while constructing the four lane highway which has caused impact on surface flow leading to serious degradation to the aquatic ecosystems of the village. Besides, unplanned construction of roads in the village has caused fragmentation of ecological habitats. The construction of the road over the Mora-Kolong has totally altered its ecology as its water flow has become almost static. As a consequence, it is gradually losing its connection with the trunk river Kolong. Earlier the Kolong recharges its left out part with numerous fishes and other aquatic animals and with an end to such an input, the ecosystem of the entire Mora-Kolong is facing tremendous problems and threats.

On the other hand, the decrease in its fish species has affected the food chain in the entire ecosystem in general and of the Mora-Kolong in particular. The number of birds that feed on the fishes like cranes, kingfishers, etc. has become less in number. Even the number of toads and crabs has also declined creating imbalances in the aquatic ecosystem and thus, the snakes that feed on the toads have automatically become endangered. Similarly, the birds and animals like eagle, *hudu, siloni,* mongoose, etc. that feed on the snakes are rarely seen now-a-days. Thus, the changes in the hydrological environment in the village have not only changed in the aquatic ecosystems but also the terrestrial ones as both are closely interlinked.

Figs. 4.18: Some selected species of fishes found in the wetlands of the village

Bighead

Baami

Bhakua

Bhedeli

Rani

Borali

Bordoia *Bagas*

Gongatup *Goroi*

Telepia or Japani Kawoi *Kajoli*

Koliajura

Kandhuli

Kholihona

Kokila dora

Koroti

Kuhi

Xol

Kusia

Lassa

Kawoi

Mirica

Misa

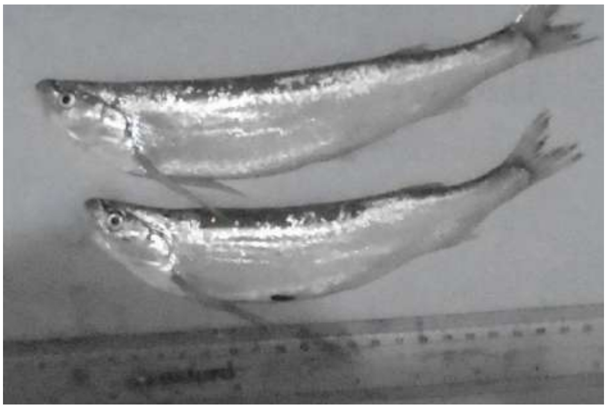
Muwa *Neria*

Patit mutura *Puthi*

Rani *Ritha*

Ronga tengera

Rou



Selekona

Seniputhi

Silver carp

Singi

Chitol

Aarie

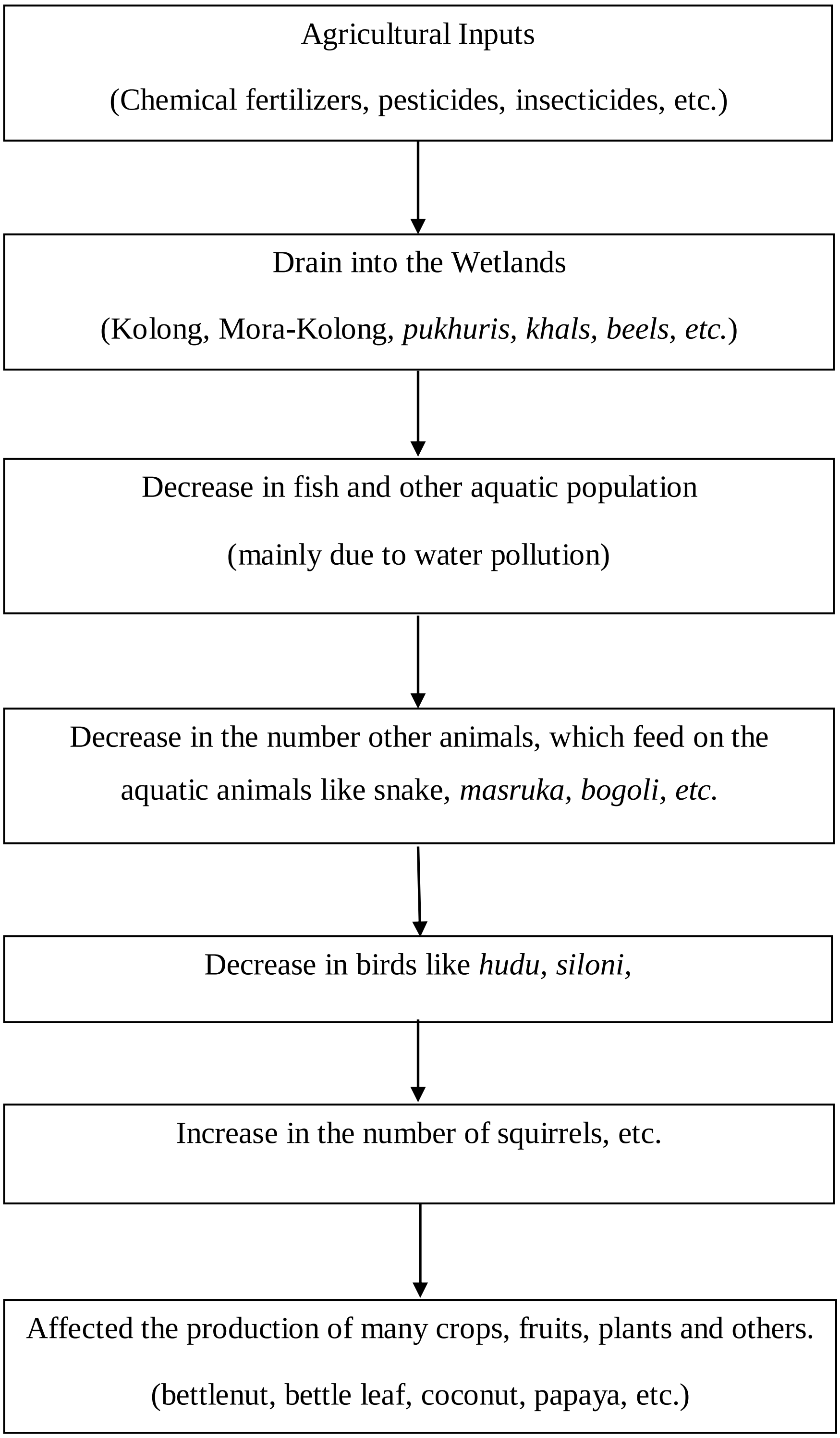


Fig. 4.19: Impact of irrational human activities on RHE and concomitant consequences

4.4 Causes of Change

The changes in rural hydrological environment are caused mainly by the anthropogenic factors although some natural causes are also responsible for such changes. It is important to mention here that earlier, during summer season, there occurred continuous spell of rainfall for almost 15 days, which is called by the local people as *satah*. During the rainy season, a number of *satahs* occurred. But, the number of *satah* in the village has decreased in recent times as told by the villagers. The irregular rainfall, disturbed surface flow and decreasing intensity of floods have made the ground water level low. Again due the installation of tube wells and wells, people no longer have to go to the river to fetch water for drinking and other allied purposes. The *morasuti or* Mora-Kolong which flows through the eastern boundary of the village was once the home of variety of fish species, aquatic plants and other animals. But during recent times, with an increase in human intervention on the *morasuti*, the dead channel has got lot of changes. People earlier built a bridge of bamboo to connect to the other side of the river. But people have now replaced this bamboo bridge by a *kutcha* road with only a small pool.

With increasing human population and concomitant growth of homesteads, people have filled up many wetlands in the village. Many *khals* of the village have also been transformed to residential lands. The decrease in fish population of the village's natural wetlands is mainly caused by the low intensity of floods.

Fig. 4.20: Human intervention in the Mora-Kolong

It is interesting to note that, the newly constructed four lane highway that passes through the middle of the village is not fitted with any pool or culvert for the flow of water from the other sides to fall into the *morasuti*. This has separated many wetland ecologies and restricts the water flow.

4.5 Impacts of Changing Hydrology on the Village's Environment

The changes in hydrological conditions in the village have not only affected its components but also all the factors that govern the manifold functions of the hydrological system. A small change in the hydrological settings can alter or misbalance the ecological equilibrium. Hence, the hydrological changes have affected the ecology of the entire village resulting in its fragmentation and also disturbed the food chain of many ecological components.

The changing hydrological conditions in the village has direct or indirect impacts on the land use pattern of the village as water levels determine the cropping patterns and practices. For instance, the *beels*, which were earlier the areas having higher water level are now being used as *bao* rice fields as the water level has become less and favors for the growth of *bao dhan*. On the other hand, a*hu dhan* which was earlier practiced on the *ahutolis* is now also cultivated in the *salitolis*. Again, in the *baotolis*, *Aijong* rice is now cultivated due to low water concentration.

It is important to note that major changes were occurred after the 1970s, when the course of the river Kolong was changed by the villagers under government support by joining the both ends of the meander channel. The immediate effect of such diversion of the channel was that the local people got relief from the devastating floods and as a result floods no longer occur with the same intensity as before. However, the major impact was the degradation of the artificially created dead channel (Mora-Kolong) due to low water discharge and velocity. The dead channel, which was earlier a perennial one, is now turning into a stagnant water body due to deposits of sands and mud at both its ends where it meets the river Kolong. Again, with the subsidence of water level in recent times the bed of the river Kolong is now used as seedbeds and also for plantation of certain crops. Thus, the changing hydrological conditions have almost changed the dynamism of the dead channel and its ecological functioning as well.

Again the construction of the four lanes highway has resulted in the filling of many *khals* due to which the number of *khals* have decreased largely in the last decade. On the other hand, many of the culverts have also been lifted up while constructing the road, resulting in differences and disturbances in the surface flow or run off.

On the other hand, due to changes in hydrological conditions, like decrease in water level of the wetlands, excessive human interventions on the peripheral areas of wetlands to mention a few, many fish species have at present become endangered or rare while some aquatic plants and animals have also been decreased in number at a rapid rate.

Another very serious effect of the changes in hydrological conditions of the village is that the water table of the village has gone down because earlier the flood water recharges the aquifers but as of now due to lesser occurrence of floods such recharging cannot be happened. Though rain water can recharge the aquifers by the processes of percolation or infiltration but it is not enough to meet the previous levels of water table.

It should be noted that the gradual decrease in intensity and frequency of floods in the village have caused the soils of the agricultural lands infertility. Due to decrease in natural soil fertility, the farmers had to adopt chemical fertilizers like urea, potash, DAP, etc. in the agricultural fields so that the production of the crops does not go lower. Though the uses of such fertilizers have helped the farmers to keep the trend of higher production, it has affected the entire rural ecosystem of the village. The inputs of chemical fertilizers, insecticides, pesticides, etc. applied unscientifically in the agricultural fields are ultimately drained into the wetlands (Kolong, Mora-Kolong, *pukhuris*, *khals*, etc.) mainly by the surface run off during the summer season which have caused serious harm to the aquatic lives and humans (Helfrich *et al*., 2009; Aktar *et al*.; 2009; Jeyaratnam, 1985; Igbedioh, 1991; Forget, 1993 and Aktar *et al*., 2009). Thus, many fishes and other aquatic animals have been disappearing from the wetland ecosystems of the village due to such unwise agricultural inputs, especially chemical fertilizers, pesticides, insecticides, fungicides, etc.

Similarly, the decrease in the number of fishes has resulted in the decrease of some of the other predatory species of animals, which feed on fishes, like water snakes, *masruka*, *bogoli*, etc. On the other hand, water snakes are mostly eaten by the birds like *siloni*, *hudu*, etc. and thus, with the decrease in water snakes, such snake eating birds have also been decreasing largely. Even many birds have died when they eat crops where chemical pesticides and insecticides are unscientifically applied. Because of the side effects of organophosphate insecticides, including disulfoton, fenthion, and parathion many predatory birds have to fall in the face of death (Isenring, 2010). With the decrease in these predatory birds, the number of squirrel and monkey population has been increasing at an alarming rate as the predatory birds and some reptiles are the main controllers of them. The increase in the number of squirrels in the village has severely affected the production of many crops, fruits, plants that grow mainly in the traditional home gardens and thereby causing a great loss to the rural farmers.

Chapter V
RURAL HYDROLOGICAL ENVIRONMENT AND LIVELIHOOD ISSUES

5.1 Adoption and Interaction

The rural hydrological environment is closely and intrinsically related to the life and livelihoods of the concerned people of a region and any change in one may alter the characteristics of the other. Wetlands being the source of livelihood have long been attracting people since the human civilization. Like the other areas of the world, people of the Brahmaputra valley have also adopted with riverine landscape to make their permanent settlement in the form of villages, and as such the concerned hydrological environment define almost all aspects of the life and livelihoods of the rural people. The livelihood pattern of the people is to a large extent depended on the hydrological conditions of an area as the people have to adopt the hydrological conditions and function accordingly. The hydrological environment of an area in turn, is affected and modified by humans through their activities. With the changes in hydrological settings over time caused by both physical and anthropogenic factors, the rural people are compelled to adapt with the new hydrological conditions to adopt a new mode of living. Thus, there occurs interaction between the people and the components of hydrological environment in the rural areas of the valley.

In case of Kahargaon village, the present village dwellers came from Titabar and Teok in 1826 (during the Yandaboo treaty) and settled down by adopting the natural hydrological settings of the village. As their primary occupation was to make utensils of bell metal, they found this place very suitable for making utensils of bell metal. Therefore, they decided to settle down in this area with the easy access of water from river Kolong. Thus, adopting the then existing natural settings of the area, people started carrying out their traditional occupation by utilizing the available resources. Thus, all the water related activities of the people centered round the river Kolong. But with the growth in the number of human population and concomitant expansion of their settlements some people started to inhabit in other parts of the village which are little far from the Kolong River. However, they started using water from the other natural wetlands. But as the water of the natural wetlands subsides during winter and therefore not sufficient and hygienic for their household activities, like washing, bathing, drinking, soaking, etc., people had decided to dug some *pukhuris* from which they could meet their requirements.

It should be noted here that before 1970s, interaction of people with the components of hydrological environment in the village was much intensive. Interaction was more with the river Kolong and its *morashuti* as people mainly used water from them for various purposes. Again, the village has few *rajohua pukhuris* (public ponds), the water of which was also used for doing all the household chores. At present, apart from having tube wells, almost all households have their own ponds, which are usually located very near to their homes. However, very recently, the interaction between the wetlands and the villagers has declined with the flow of time because of the installation of tube wells and wells.

Even the interaction of people was more with the *khals, beels* and *morasuti* (Fig. 5.1) for catching fishes and the other purposes being same with the *pukhuris.* The pattern of interaction is different with different wetlands. *Khals* are used for catching wild fishes, edible vegetation, like *makua* (*Nymphaea lotus*), *kol-mou* (*Ipomoea aquatic*), *helesi*, etc. *Pukhuris* are used for domesticating fishes for own consumption and occasional sell.

It is noteworthy that the decrease in dependency on the natural wetlands (Fig. 5.2) has resulted in negligence to the wetlands and ultimately caused ecological degradation in the village. For example, earlier, as the people used water of the Mora-Kolong so they tried to keep the water clean by not disposing any wastes/garbage to the river, but as soon as people started drinking water from tube wells and wells, it no longer became their source of drinking water and also for other uses. As a result, such steps or precaution to keep the water clean is hardly seen. Presently, throwing garbage or other polluting substances in the river has become quite common.

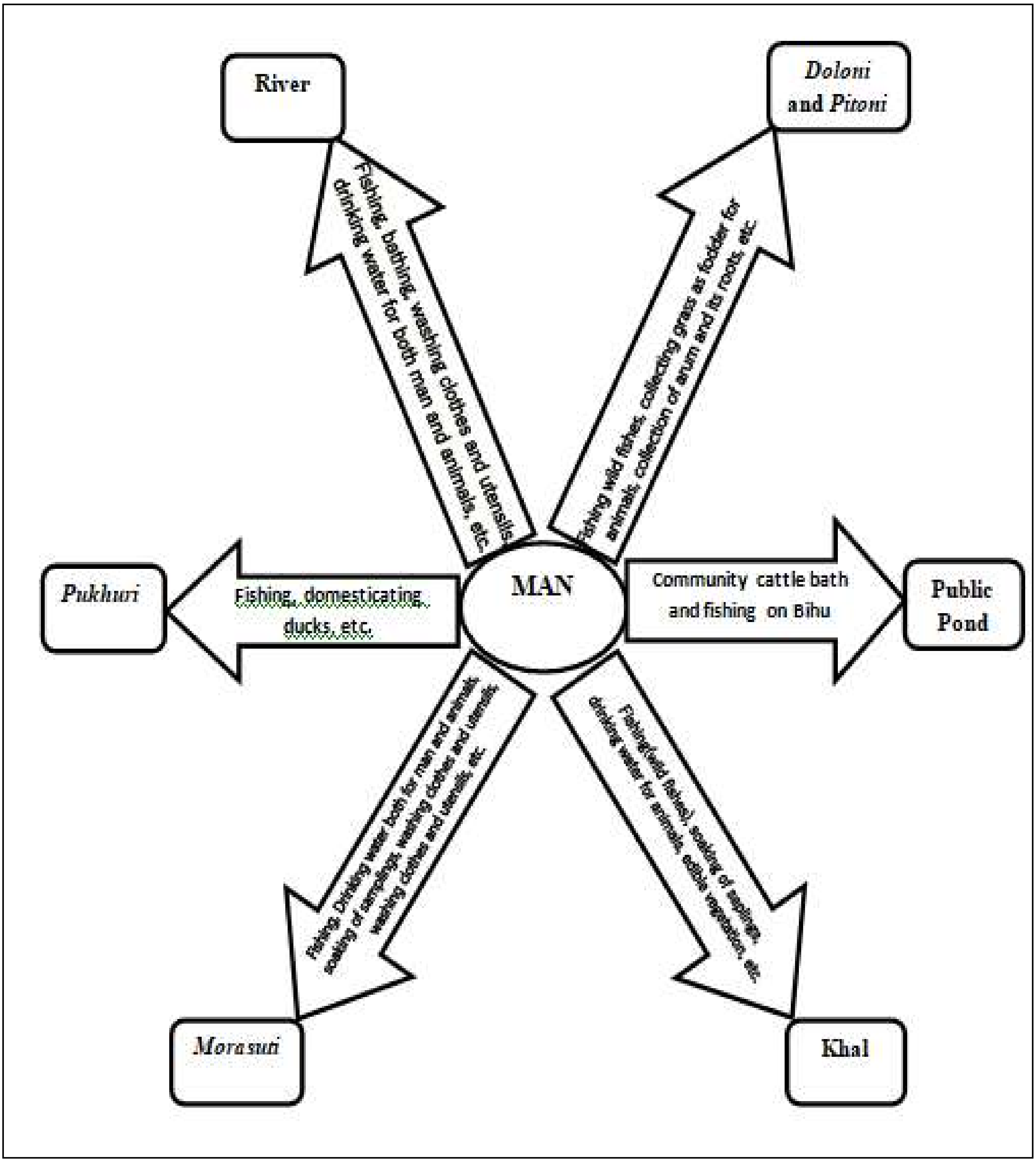


Fig. 5.1: Utility pattern of wetlands before 1970s

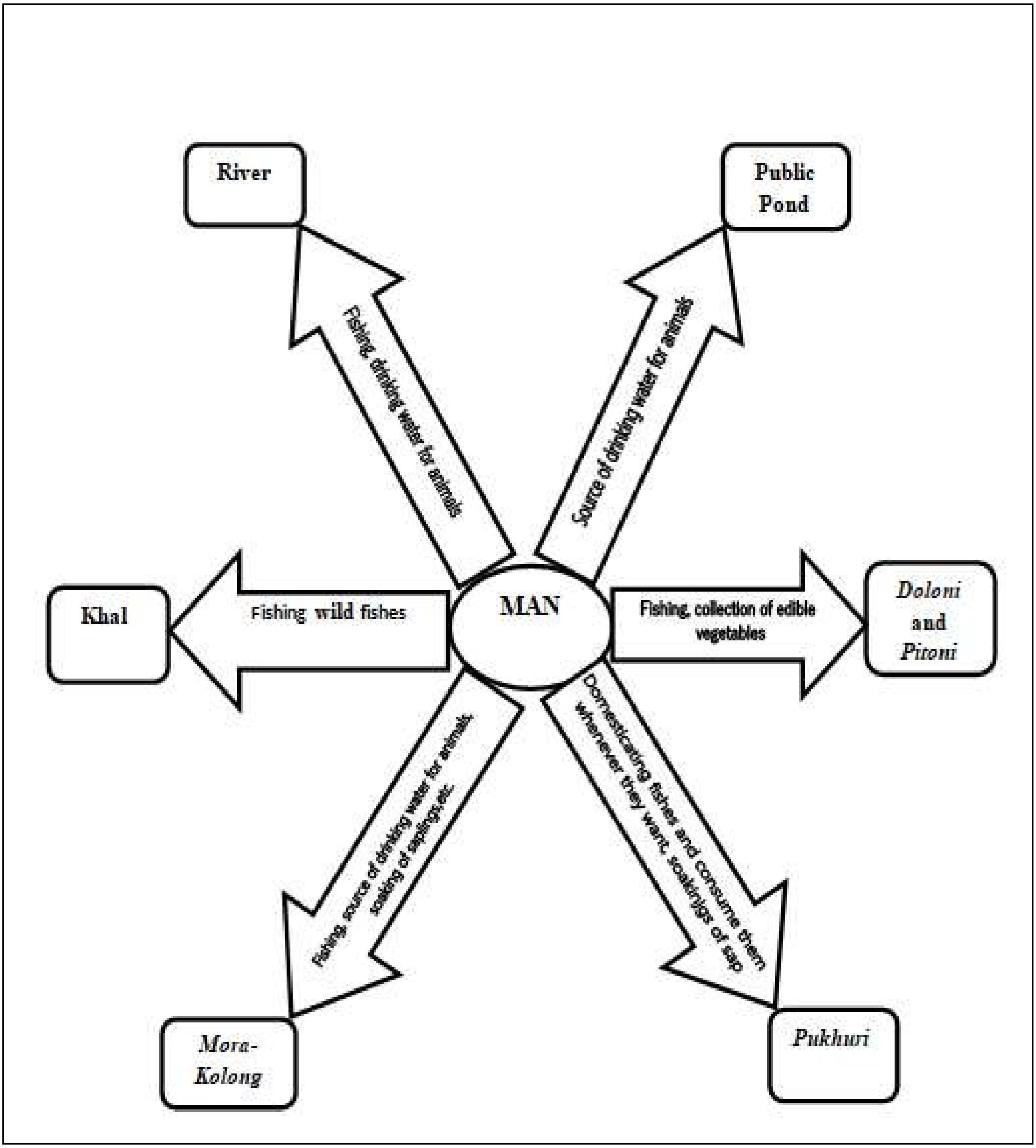


Fig. 5.2: Utility pattern of wetlands after 1970s

5.2 Adaptation to the Hydrological Environment

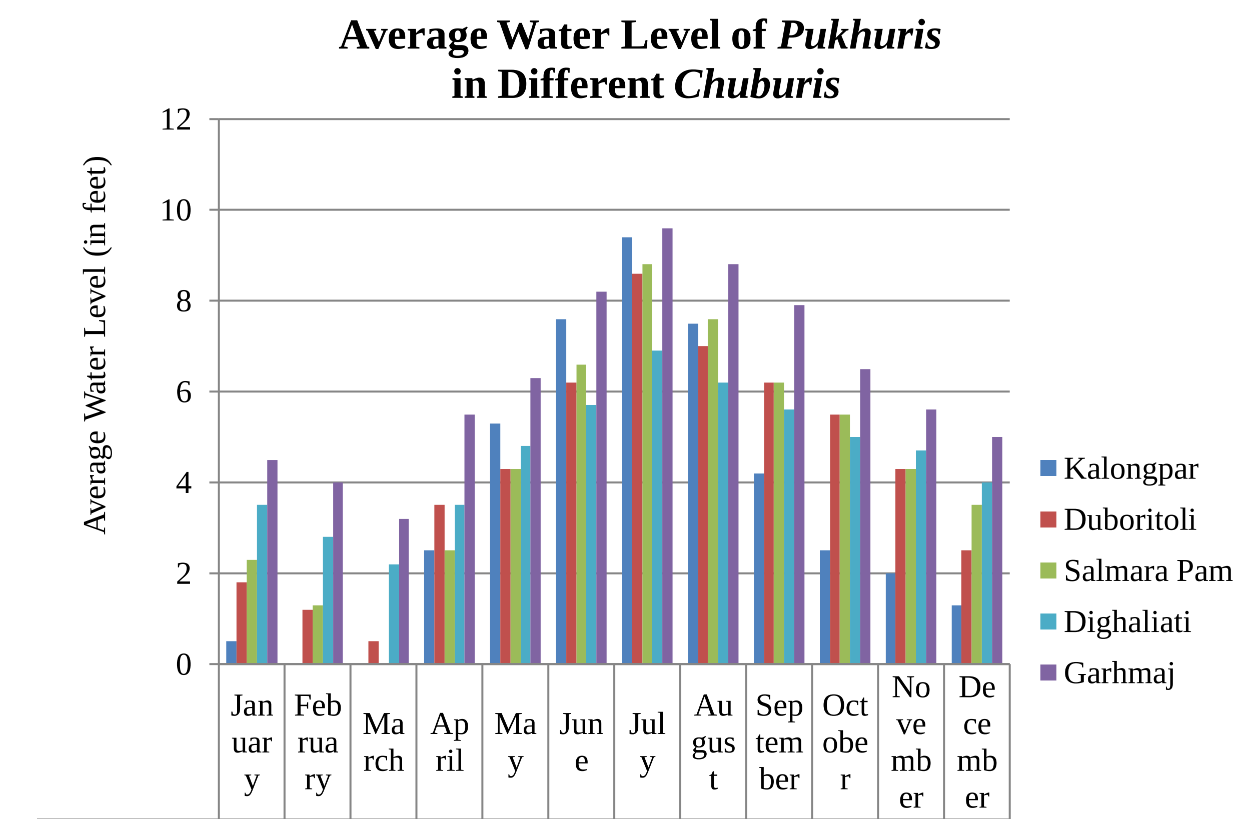
The people have well-adjusted with the changing hydrological environment of the village. Their mode of adjustment is quite different owing to different hydrological parameters. For instance, people's adjustment with the variation of rainfall in time is different to the adjustment of changes in surface flow.

In Kolongpar and Garhmaj, as water is hardly retained in the *pukhuris*, so carrying out pisciculture was very challenging, therefore, people have dug their *pukhuris* to a much greater depths so that more water can be stored in them to use even during the driest months. There are only three (3) *pukhuris* in Kolongpar whose depths are more than 12 feet. Thus, pisciculture is carried out in those *pukhuris*.

Again, in Garhmaj, there are seven (7) *pukhuris*, which have been dug with depths more than 10 feet so that water can retain in them. It is noteworthy that, out of these seven (7) *pukhuris*, four (4) of them have been newly dug but the rest three (3) *pukhuris* were older ones with lesser depths which have been further dug into more depths using backhoe diggers.

People in the village have also well-adjusted with different wetlands and their fluctuating water levels. Thus, if we look at the comparative picture of the water level of the wetlands in each *chuburis*, especially *pukhuris* and *khals*, then we will find that the water level of the *pukhuris* of Kalongpar and Salmara Pam completely dries up during February-March. Hence, people in Kolongpar start fishing mainly from the month of December and ends it in January as water level remains at 1.3 feet in December and thereafter in February and March, no fishes survive in the *pukhuris*. Fishes generally need a minimum water level of 2-2.5 feet to survive well in the *pukhuris*, so, whenever the water level goes down below that minimum level, people starts fishing. In Salmara Pam, the water of the *pukhuris* remains at 2.3 feet in January and 1.3 feet in February but during the month of March the water dries up. Therefore, people in this *chuburi* start fishing from January and finishes it before March.

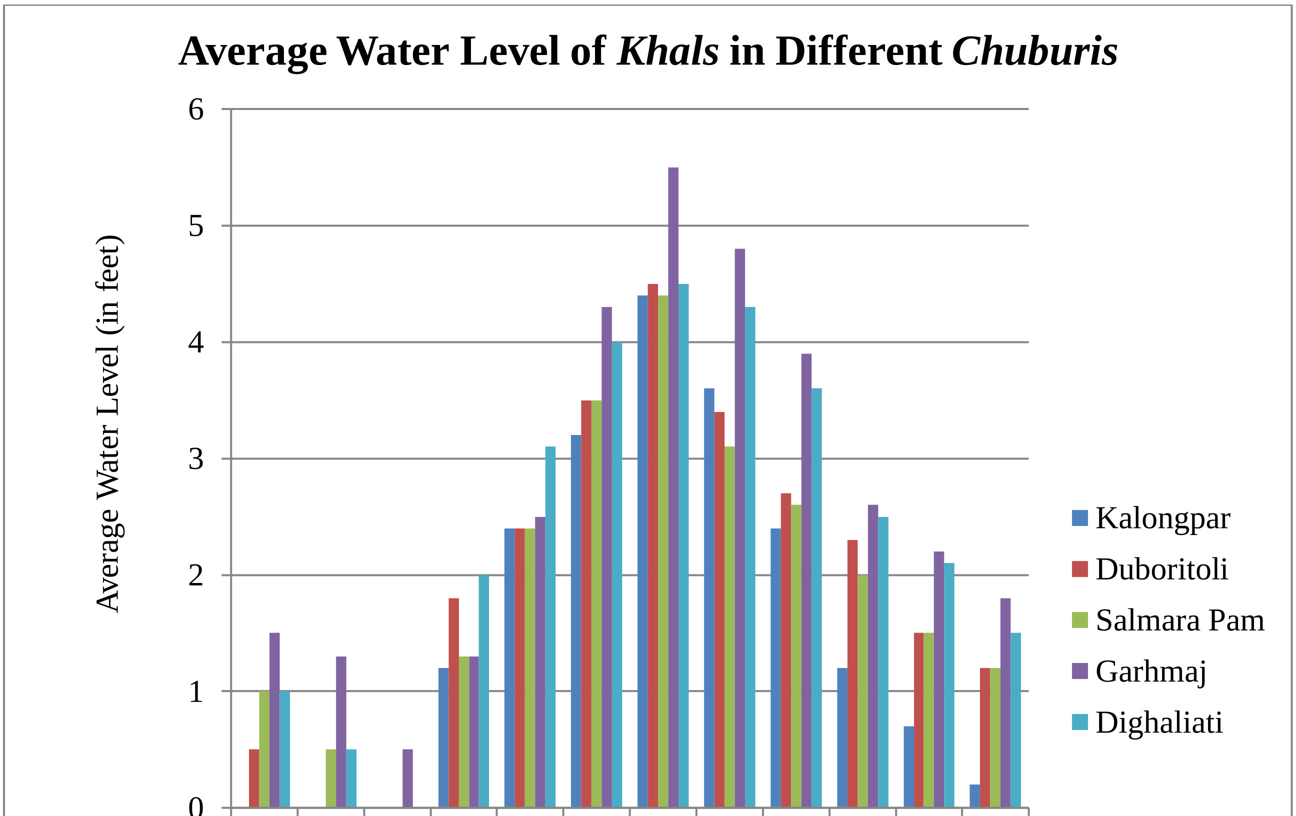
Again in the northern part of Duboritoli, water of the *pukhuris* and *khals* dry up completely during the dry season, therefore the owners catch the fishes usually in mid-January before the water level of the *pukhuris* and *khals* goes down below 2 feet. Contrary to this, on the southern part of Duboritoli, the water level of the *pukhuris* does not dry up completely but remains at a level of 1-1.5 feet. Even in the *pukhuris* and *khals* also, people catch the fishes as soon as the water level goes down below 2 feet which usually happens in the month of last week of February. As the *pukhuris* in such a situation gets muddy water where fishes cannot move freely and as a consequence, the fishes die out of oxygen. So, people in this *chuburi* catch fishes mainly from January and ends it by the end of February. The water level of the *pukhuris* in northern Duboritoli remains at 1.8 feet in January, so it becomes convenient for the owners to catch the fishes in less water. Thus, the people in Duboritoli have also tried to adjust themselves to the shrinking water level in the *pukhuris* and *khals*.



	January	February	March	April	May	June	July	August	September	October	November	December
Kalongpar	0.5	0	0	2.5	5.3	7.6	9.4	7.5	4.2	2.5	2	1.3
Duboritoli	1.8	1.2	0.5	3.5	4.3	6.2	8.6	7	6.2	5.5	4.3	2.5
Salmara Pam	2.3	1.3	0	2.5	4.3	6.6	8.8	7.6	6.2	5.5	4.3	3.5
Dighaliati	3.5	2.8	2.2	3.5	4.8	5.7	6.9	6.2	5.6	5	4.7	4
Garhmaj	4.5	4	3.2	5.5	6.3	8.2	9.6	8.8	7.9	6.5	5.6	5

Fig. 5.3: Monthly variation in water levels of *pukhuris* in different *chuburis*

In Garhmaj and Dighaliati, people in January practice fishing mainly on the occasion of *Magh Bihu*. The water level of the *pukhuris* in these *chuburis* remains lowest at 2.2 feet in Dighaliati and 3.2 feet in Garhmaj in the month of March. As there is sufficient water in the *pukhuris* of both the *chuburis*, therefore people does not catch all the fishes instead, some fishes are left out in the *pukhuris* so that they grow more by the next year and the owners generate more income out of them.



Chuburis	January	February	March	April	May	June	July	August	September	October	November	December
Kalongpar	0	0	0	1.2	2.4	3.2	4.4	3.6	2.4	1.2	0.7	0.2
Duboritoli	0.5	0	0	1.8	2.4	3.5	4.5	3.4	2.7	2.3	1.5	1.2
Salmara Pam	1	0.5	0	1.3	2.4	3.5	4.4	3.1	2.6	2	1.5	1.2
Garhmaj	1.5	1.3	0.5	1.3	2.5	4.3	5.5	4.8	3.9	2.6	2.2	1.8
Dighaliati	1	0.5	0	2	3.1	4	4.5	4.3	3.6	2.5	2.1	1.5

Fig. 5.4: Monthly variation in water levels of *khals* in different *chuburis*

Thus, it is found that as water of the *pukhuris* does not dry up completely in Dighaliati and Garhmaj, they are provided with more fish seeds than those in Kolongpar, Duboritoli and Salmara Pam. The *pukhuris* with more water can result in better growth of fishes and as such, help the owners to earn a good sum of rupees from it.

On the other hand, the scenario is quite different in case of the *khals* in the *chuburis* of the village. The water level of the *khals* during the winter season completely dries up in Kolongpar, Duboritoli, Salmara Pam and Dighaliati. The water of the *khals* in Kolongpar dries up completely from the month of January till the end of March. While, the water of the *khals* in Duboritoli dries up completely from February till March but in Salmara Pam and Dighaliati, it dries up only in the month of March till the onset of pre-monsoon rain. It is interesting to note that the water of the *khals* in Garhmaj does not dry up completely and goes down to as low as 0.5 feet in March.

Some wild fishes can survive even in low water conditions with a limited oxygen level. The *khals* in each of the *chuburis* are drained out artificially by using various traditional ways and means and thus fishes are trapped. Some of the fishes like *sengeli*, *goroi*, *magur*, *kuchia, bangi, tora, botia*, etc. even can survive for a few days at less than 1 feet of low water where there is very low supply of oxygen.

5.2.1 Hydrology and Land Use Pattern

Land use pattern in the village is determined largely by the rural hydrological conditions. The *foringtolis* or *bam-mati* are used for settlement purposes and construction of other elements of the cultural landscape as these lands are higher in elevation and flood water cannot easily inundate such lands. Therefore, people for building houses, schools, *namghars, roads*, etc. use *foringtolis*. Again, the winter rice fields are relatively low-lying lands where rain/flood water rises up to 2.5 feets during summer. Nearly, 70% of the village's agricultural lands are *salitolis.* The autumn rice is cultivated in comparatively higher elevated lands that the winter rice fields. Again, during the months of February- March when the rainwater on the *salitolis* dries up, autumn rice (*ahu dhan*) is sown and it is harvested during the months of July-August. Another typical Sali rice variety, locally called as *bao dhan* is cultivated in the low-lying areas than the winter rice fields where floods and waterlogged conditions make cultivation of other rice difficult (Bhagabati *et al*., 2012).

Thus, the land use (LU) pattern in the village during summer and winter seasons is mainly determined by the level and availability of surface water on the fields. Land use pattern in the village during summer is mainly dominated by the cultivation of *sali* rice (winter rice) and some parts of land having sandy soil is used to cultivate *ahu* rice (autumn rice). It is worth mentioning that though the lands on the northern part of the village on the southern bank of river Kolong have sandy soil creating suitable conditions for the cultivation of *ahu* rice, but the farmers as well as the land owners don't want to practice *ahu* rice cultivation because of the fear of loss of the crops in floods. On the other hand, some of the farmers grow vegetables during the season for both consumption and sale.

The Kolongpar *chuburi*, located in the northern part of the village and lying to the south of the river Kolong has relatively lower arable lands as because water doesn't retain in that area mostly due to sandy soils. During summers, cultivation is hardly possible as floodwater inundates the area very often. Again, during winters, as soon as the water level of the Kolong subsides, the surface water storages in the peripheral areas gradually dries up and thus, provide less scope for cultivation. Thus, only mustard is cultivated in winter. Agriculture is very intensive in Duboritoli *chuburi* as the agricultural fields are composed of fertile alluvial soils and most of the farmers of the village are settled in this *chuburi*. Rice, mustard, jute and black gram are the dominant crops in the area. *Sali rice* is the main crop of the region, which is dependent on rainwater. Salmara Pam has much waterscape like *Kherxona beel* and *Hatigeya beel*. These two *beels* are nothing but 'seasonal wetlands' in which the fields remain covered by water for almost six to seven (6-7) months of the year. Thus, cultivation of rice, especially *sali* rice becomes very difficult in the area. Autumn rice (*ahu dhan*) and bao rice (*bao dhan*) are commonly grown here.

Table 5.1: Areas under different crops in each *chuburi*, 2017

Crops	**Area (in ha) under crops in each *chuburi***					
	Kalongpar	**Duboritoli**	**Salmara Pam**	**Garhmaj**	**Dighaliati**	**Total**
Rice	4.01	32.76	0.54	15.70	0.0	53.01
Mustard	7.02	15.26	1.74	4.68	0	28.71
Sugarcane	1.33	1.94	0.26	1.47	0	5.02
Jute	1.40	6.76	0.67	2.41	0	11.25
Black Gram	0.06	4.08	0	0	0	4.14

Vegetables	3.01	1.60	0	0.53	0	5.15
Others*	0.80	1.47	0.26	1.87	0.60	5.02
Total	17.65	63.89	3.48	26.68	0.60	**112.31**

Source: Field Survey, 2017-2018; *beetle nut, bettle leaf, banana tree, lemon, etc.

Again, rice is an important crop cultivated in Garhmaj. During winter, the fields remain yellowish with the cultivation of mustard. However, it is interesting to mention that in Dighaliati, there has been no cultivation of crops other than bettle nut, bettle leaf, banana tree, lemon, etc. Thus, this *chuburi* has the least contribution to the agricultural economy of the village.

Out of the *chuburis*, Duboritoli has the highest land (63.89 ha.) under agriculture while Dighaliati has the least land under agricultural sector. It is because Dighaliati is mainly dominated by the elements of cultural landscape like National Highways, market area consisting of groceries, restaurants and other shops, settlement area, schools and a primary health centre.

The Gross Cropped Area (GCA) in the village has been found as 112.3101 ha. while, the Net Sown Area (NSA) in the village is found to be 85.42918 ha. Thus, cropping intensity is calculated with the help of the following formula-

$$\text{Cropping Intensity (CI)} = \frac{\text{Gross Cropped Area (GCA)}}{\text{Net Shown Area (NSA)}} \times 100$$

Cropping intensity is highest in Duboritoli, *which is 171.35%, followed by Kalongpar (149.81 %)*, and it is lowest in Dighaliati (4.34%) (Table 5.2). Thus, the overall cropping intensity in the village is found as 131.47%.

Table 5.2: Cropping intensity in each *chuburi*

Chuburis	**Net sown area (in ha.)**	**Gross cropped area (in ha.)**	**Cropping intensity (%)**
Kalongpar	11.78	17.65	149.81
Duboritoli	37.28	63.89	171.36
Salmara Pam	3.61	3.48	96.29
Garhmaj	18.87	26.68	141.34
Dighaliati	13.86	0.60	4.344
Kahargaon	**85.43**	**112.31**	**131.47**

Source: Field Survey, 2017-2018

It is interesting to note that the agricultural production is highest in Duboritoli as it has the largest area under agriculture, followed by Kalongpar, Garhmaj, Salmara Pam and Dighaliati. The reason behind this is that Duboritoli has relatively favorable hydrological conditions for developing agriculture as it gets water from both the Kolong and Mora-Kolong. Besides, soil quality and fertility, concentration of farmers have also contributed to the higher production of crops in Duboritoli.

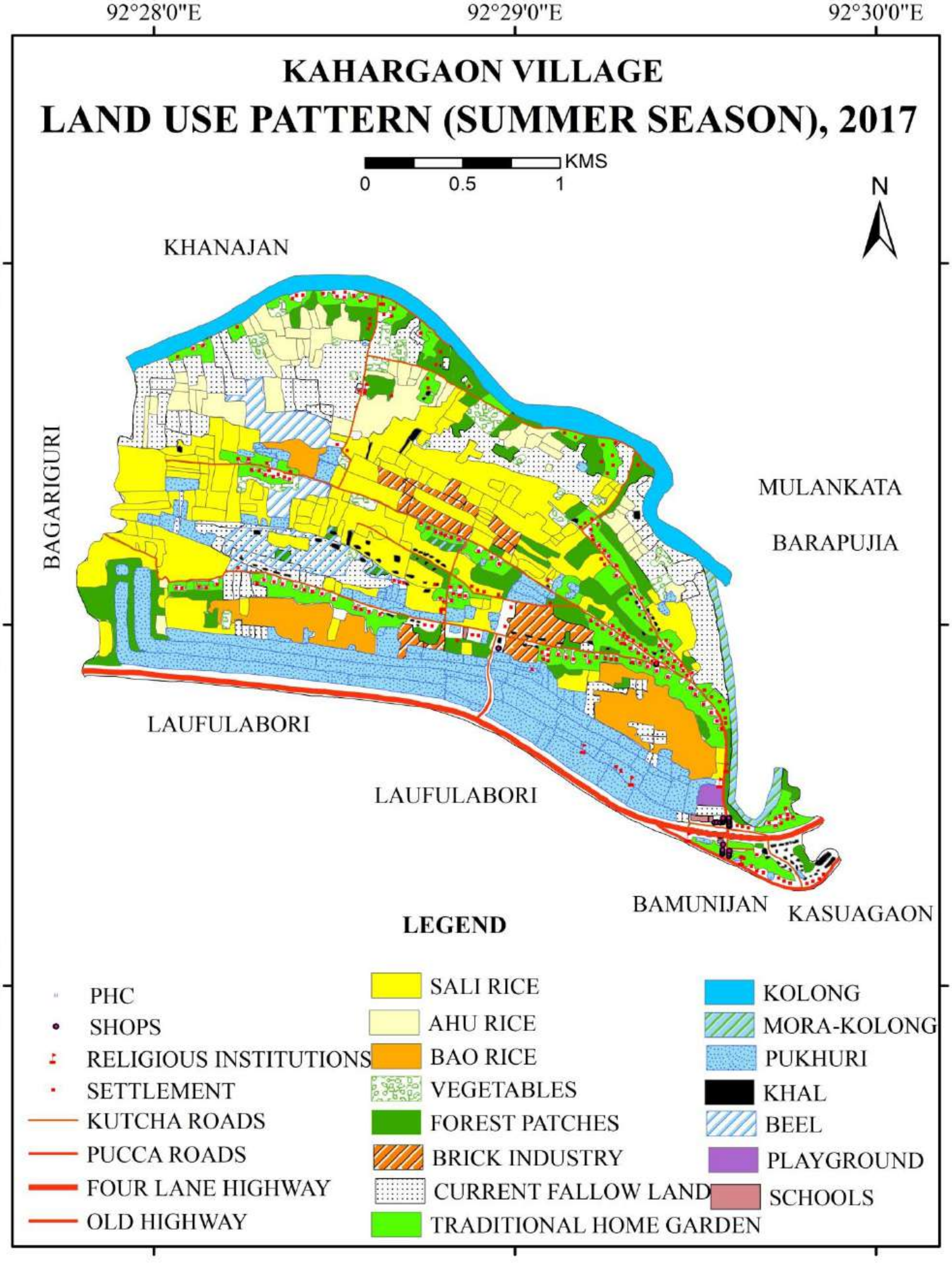


Fig. 5.5: Land use pattern in summer season, 2017

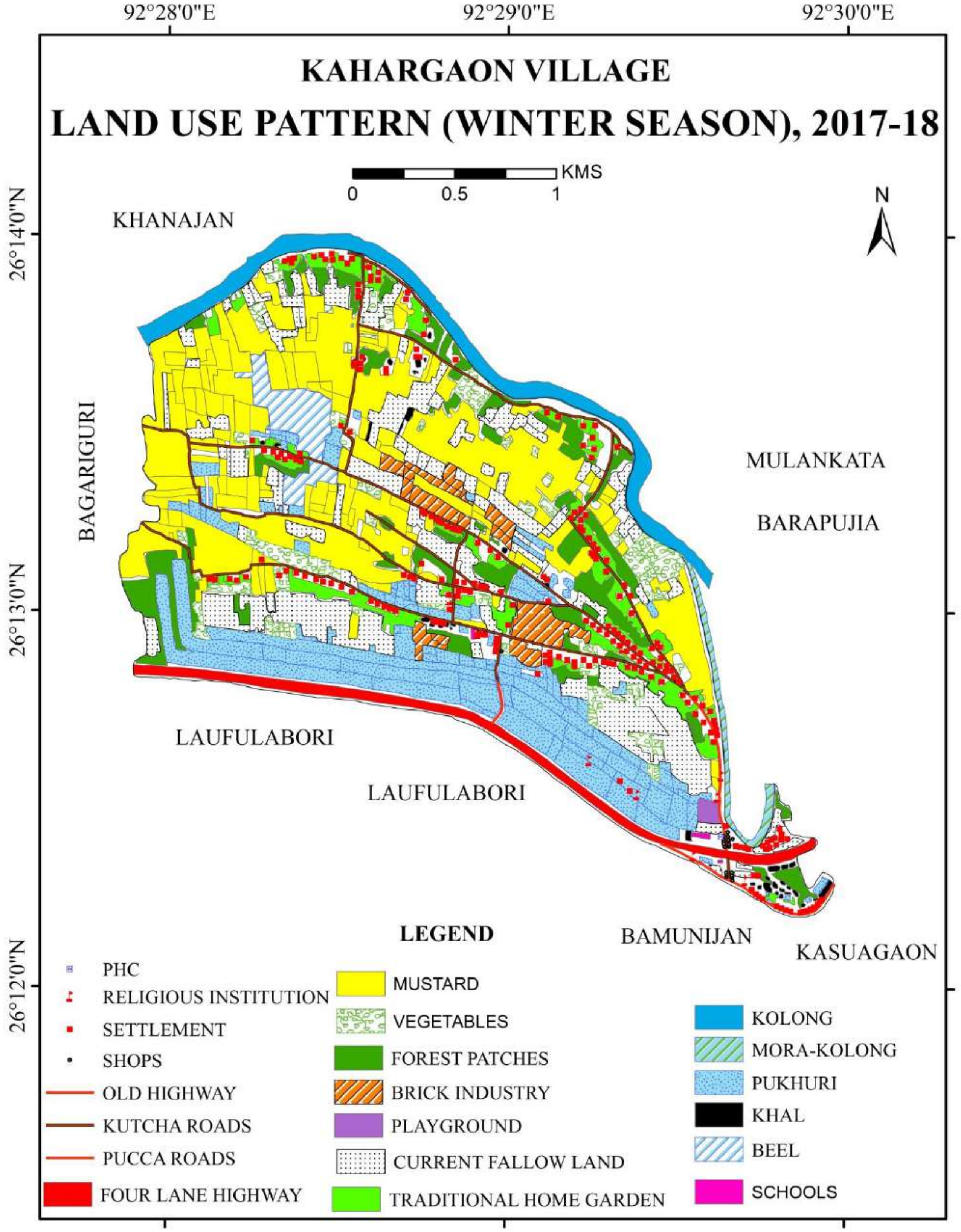


Fig. 5.6: Land use pattern in winter season, 2017

On the contrary, agricultural landscapes in the village during winter are dominated by the cultivation of *rabi* crops, especially mustard followed by sugarcane and other crops. Growing of winter vegetables like potato, coriander, cabbage, cauliflower, pea, etc. is another important characteristic feature of winter agricultural landscapes. While some lands covered by water are used for *bao* rice (summer rice) cultivation. The southern parts of the village are mostly covered by government *pukhuris* (ponds) which are used as fish breeding centres.

It is important to mention here that due to decrease in water level and shrinking productivity some *bao* rice fields of the village have been converted into *pukhuris* by building up segmented embankments. This transformation has gained them much profit than rice production

It has been going on since ages that whenever there is dearth of rainfall and consequent drought-like conditions in the agricultural fields, the farmers used to irrigate their fields by supplying water from the *pukhuris*, *khals*, Kolong, Mora-Kolong, etc. The farmers sometimes dug out drains from these storages to their fields where the farmers pour the water in the mouth with the help of some traditional equipments and the water is automatically drained into the fields. Thus, the farmers used to cope up with the drought-like conditions by utilizing water from the surface water storages and produce sufficient enough to sustain themselves. But in the late 1980s, there has been change in the adaptation method to the scanty rainfall conditions as few farmers have installed tube wells in their agricultural fields to provide water during dry conditions. Again in the beginning of the 20th century, diesel water pumps (DWP) have been installed in the fields to spread water. Besides, owing to the nature of rainfall in the entire region, people of the village, like other parts of Assam, have also well adapted to the rainfall pattern. Assam-type houses have mostly been built in the village so that the rain water can easily flow down to the ground without any stagnation on the roof. Similarly, the morphology of the settlements in the village is also much worthy to pen it down. Each of the household having a courtyard is a common characteristic of the village. It is quite interesting to note that the courtyards are sloping with micro differences in elevation so that rain water can easily flow out of the settled area without causing any inundation.

Again, the farmers have maintained another way of controlling and utilizing surface flows in the agricultural fields. The agricultural fields have dykes which bound the rain water and help the farmers in crop production. The farmers with their traditional or ancestral knowledge have made cuts in those dykes so that water can flow following the slopes with micro variations in elevations. This activity is so well organized that each agricultural plot separated by internal dykes are well entrained with natural water supply.

On the other hand, during mid-July when the water of the winter rice fields rises about 55-63 cms approximately, then the farmers used to plough their lands as the soil particles get loosened as soon as rain water percolates through them thereby helping in tilling of the soils. Moreover, when the water level increases to about 40-50 cms then the farmers used to plough and harrow the lands again. This usually happens from the second week of August till the beginning of the fourth week. From last week of August, transplanting of rice saplings is carried out till third week of September when the water level remains at almost 18-38 cms. After transplanting the saplings, the growing period starts where the water level remains at 12-20 cms. The growing period is usually the period from the third week of October to the first week of November. Ripening period occurs from the second week upto the end of November when the field remains almost dry. The final or the harvesting period takes place in December with no water on the field and thus, they can harvest the crops easily (Fig. 5.7).

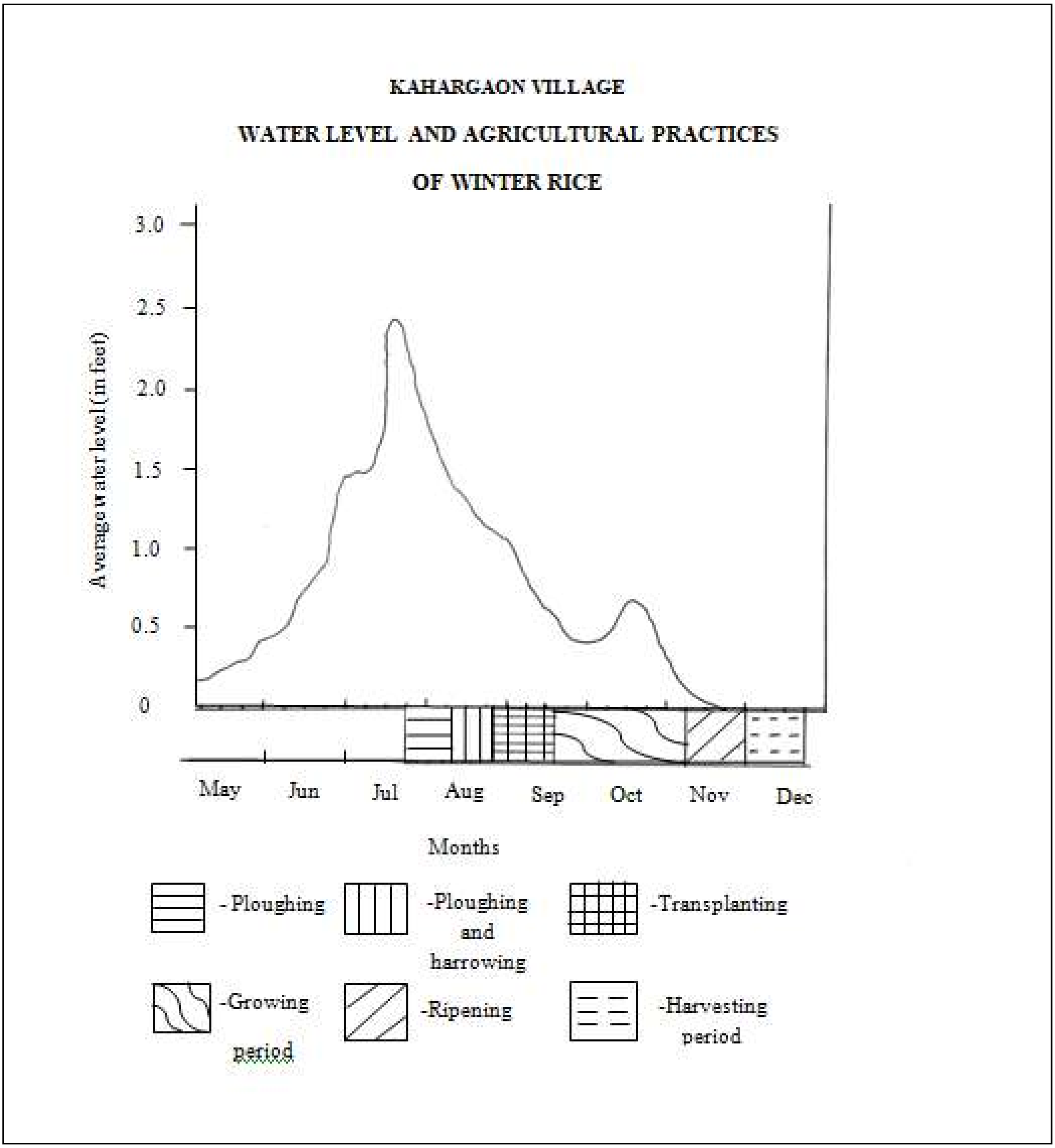


Fig. 5.7: Water level and agricultural practices for winter rice

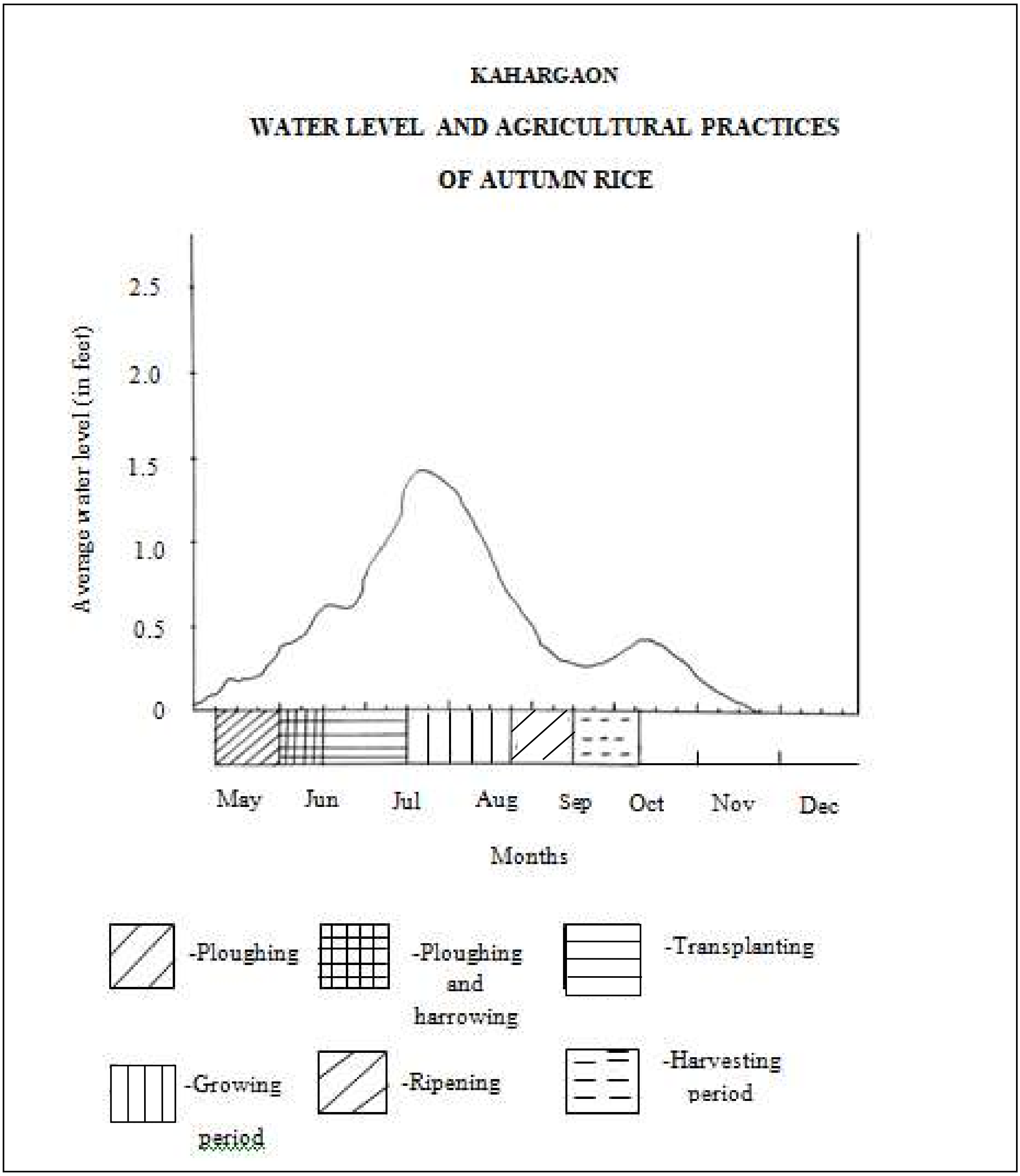


Fig. 5.8: Water level and agricultural practices for autumn rice

Again from the second week of May when the water on the autumn rice fields is about 5-6 cms, then the farmers use to plough the lands and when the water level increases to about 18-24 cms then the farmers use to plough the land again and harrowing is also done along with it. This happens from the first week to the beginning of the third week of June. Again from mid-June, transplanting of rice saplings is carried out till the second week of July when the water level remains at almost 35-45 cms. After transplanting the saplings, the growing period starts where the water level remains at 25-35 cms. The growing period is usually the period from the second week of July to the third week of August. Ripening period on the other hand, occurs from the later part of August upto mid-September when the field remains at about 10-22 cms. The final or the harvesting period takes place from mid-September to mid-October where the fields remain damped with water even less than 1 cms (Fig. 5.8). Thus, the people have adapted well with the existing hydrological patterns of the village where they have developed new methods and techniques on their own and practice different agriculture having different water levels.

Another very important thing to mention is that the foundation or altar of the houses made by some of the villagers is only about 1 feet from the ground where flood water can easily inundate their houses. But, in the 1990s many people raised their foundations to a considerable heights so that flood water cannot inundate or penetrate inside their houses. This activity is especially seen in Kolongpar, Duboritoli and Salmara Pam where the foundations of the houses have been raised to a maximum of 4-4.5 feet in some cases because these three are frequently flooded *chuburis* where flood water reaches upto a maximum height of 3-5 feet. While in Garhmaj and Dighaliati, it has been raised to a maximum of 2 feet because in both these *chuburis*, flood water level has not exceeded the height of 2 feet.

5.3 Functions of Rural Hydrology to Rural Economy and Culture

The rural hydrological components, viz. rainfall, surface water storages, evaporation, infiltration, etc. have their own specific role in the hydrological cycle, which also determines the way of livelihood of the people. Human responses to the concerned rural hydrological environment vary according to varying hydrological situations. Similarly, the functions of rural hydrology to economy, culture and ecology are not uniform. Wetlands provide to the local people a range of goods and services for their livelihoods. Regional wetlands are integral parts of the larger landscapes whose functions and values to the people in these landscapes, depend on both their extent and location (Prasad *et al.*, 2002; Mitsch *et al.*, 2009; Sulphey and Safeer, 2017). Each wetland thus has its own significant functions in the landscape. Wetlands perform various roles, such as recycle nutrients, purify water, attenuate floods, maintain stream flow, recharge ground water, and also serve in providing drinking water, fish, fodder, fuel, wildlife habitat, control rate of runoff in urban area, buffer shorelines against erosion and recreation to the society (Prasad et *al.*, 2002).

Rainwater, being one of the main components of rural hydrology has the most important role to play in economic and cultural fronts of the area. Many day-to-day activities are depended on rain water. Apart from other dependency, agriculture of the area is largely dependent on rain water as rain water determines cropping pattern and also practices. Rural agriculture is heavily tied to the monsoon rainfall and thus production of crops differs with the amount of rainfall in a year. If the rainfall received during their plantation and growing period is adequate, then it will ensure a higher production provided other conditions being normal.

The other components of rural hydrology, which has their influence on the economy, and culture of the village are the diverse wetlands while the role of underground water cannot be denied in this regard. All these components in the village are naturally set in such a way that they provide congenial conditions for cultivation of various crops, including vegetation. However, it should be mentioned that the hydrological conditions in the village varies owing to the changes in seasons. In summer, the rainfall and the temperature conditions help the farmers in growing sugarcane, jute, rice, etc. Similarly, the relatively drier conditions help the farmers grow mustard and some winter vegetables. The farmers thus can maintain self-subsistence from their agriculture while the excess production is sold in the nearby markets and thus they gain income.

The wetland supports some of the rare fish species in the village maintaining the richness in its ecological as well as biological fronts. The availability of large number of fish species also facilitates people with quite a number of income sources either directly or indirectly. Fishing is an age-old activity that has been practicing since the inception of the settlements in the village using different traditional tools and techniques (Fig. 5.9) and has always been one of the major sources of income. This traditional activity has been helping the farmers in generating income thereby boosting the economic conditions of the people in particular and the village in general.

It has been known that the first people who settled in the village were due to the suitable location of the place with the river Kolong and favorable and their desired soil quality. The people first settled in the village because they got easy access to river water which is needed in making bell metal utensils as they were originally the makers of such utensils. Such suitable conditions help in the growth of this business which helped the people in generating income and maintain their livelihood. Thus, the wetlands not only provide the people with access to water facilities but also offer a number of opportunities through which people can make a way to sustain their livelihood.

The hydrological settings of the village have its own significance. Some people after having the ceremonial functions either at home or at public places let the offerings like flower and other ritual things flow in the wetlands, especially Kolong and Mora-Kolong. Besides, the banks of the wetlands also favor for the growth of many edible vegetation, such as*helesi*, *mati kaduri*, *bor mani-muni*, *xoru mani-muni*, *kolmou*, *makua*, *leheti*, *morolia*, etc. which acts as source of nutrients to the people. Even during typical Assamese marriages, usually the mother of the bride or groom used to collect water in a pot made of bell metal from the nearby wetlands which is considered as holy and that water has to be used by the respective bride or groom for bathing. It should be mentioned here that the people of Kolongpar and Duboritoli used the water of Kolong for this purpose while the people of Salmara Pam and Garhmaj used to collect water from the *pukhuris* and *khals*. Sometimes, the people of Duboritoli also used the water of the Mora-Kolong. On the other hand, the people of Dighaliati used the water of Mora-Kolong and *pukhuris* as the Mora-Kolong is located nearby they don’t go for the Kolong. However, this ritual is now being replaced by collecting water from the tube wells and even electric motor pumps.

Fig. 5.9: Fishing in different wetlands practiced using different tools and techniques

The role of wetlands to rural economy and culture is very significant and has a very long tradition which needs eagle eyes to explore them in-depth. The wetlands of the village before 1970s were the main source of water, so, these wetlands play very important role in the livelihoods of the people in many aspects. All the household or outdoor activities of the people are centered around the river and other wetlands.

Fig. 5.10: Utilization of water for various purposes

Besides, humans have responded differently to different components of rural hydrology and their different statuses. As in case of water use, people have different utilization patterns in different *chuburis*. The people of Kolongpar mostly use the water of tube wells and only one household use electric motor pump (EMP) (Table: 5.3). Thus, the role of wetlands in water usage has been replaced by the use of underground water sources since 1952 as people started using water of the tube wells, ring wells and EMPs. Hence, in the present context underground water sources play a very significant role in various uses of their day-to-day lives.

Table 5.3.: Water use by households for different purposes in each *chuburi*

Purposes of water Use	***Chuburis***				
	Kalongpar	**Duboritoli**	**Salmara Pam**	**Garhmaj**	**Dighaliati**
Drinking	K=0, P=0, Kh=0, TW=32, RW=5, EMP=1	K=2, MK=0, P=0, Kh=0, TW=62, RW=0, EMP=7	P=0, Kh=0, B=0, TW=16, RW=0. EMP=1	K=0, MK=0, P=0, Kh=0, TW=66, RW=0, EMP=8	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14
Bathing	K=7, P=0, Kh=0, TW=32, RW=5, EMP=1	K=5, MK=4, P=2, Kh=0, TW=62, RW=0, EMP=7	P=0, Kh=0, B=0, TW=16, RW=0, EMP=1	K=0, MK=0, P=2, Kh=0, TW=72, RW=0, EMP=8	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14
Washing Clothes	K=10, P=0, Kh=0, TW=32, RW=5, EMP=1	K=4, MK=3, P=2, Kh=0, TW=62, RW=0, EMP=7	P=0, Kh=0, B=0, TW=16, RW=0, EMP=1	K=0, MK=0, P=1, Kh=0, TW=72, RW=0, EMP=8	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14
Washing Utensils	K=2, P=0, Kh=0, TW=32, RW=5, EMP=1	K=0, MK=0, P=0, Kh=0, TW=62, RW=2, EMP=7	P=0, Kh=0, B=0, TW=16, RW=0, EMP=1	K=0, MK=0, P=0, Kh=0, TW=73, RW=0, EMP=8	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14
Agriculture	K=16, P=2,	K=2, MK=3,	P=3, Kh=4,	K=0, MK=0,	K=0, MK=0,

	Kh=8, TW=7, RW=0, EMP=0 DWP=4	P=8, Kh=16, TW=14, RW=0, EMP=0 DWP=12	B=6, TW=0, RW=0, EMP=0, DWP=0	P=11, Kh=26, TW=13, RW=0, EMP=0, DWP=15	P=0, Kh=0, TW=0, RW=0, EMP=0 DWP=0
Drinking Water for Cattles	K=11, P=0, Kh=0, TW=13, RW=7, EMP=1	K=6, MK=7, P=7, Kh=21, TW=33, RW=2, EMP=7	P=3, Kh=4, B=5, TW=4, RW=0, EMP=1	K=0, MK=0, P=14, Kh=23, TW=21, RW=0, EMP=8	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14
Soaking	K=3, P=15, Kh=15, TW=0 RW=0	K=2, MK=14, P=28, Kh=37, TW=0, RW=0	P=2, Kh=3, B=15, TW=0, RW=0, EMP=0	K=0, MK=0, P=24, Kh=36, TW=0, RW=0	K=0, MK=2, P=4, Kh=0, TW=0, RW=0, EMP=0

Source: Field Survey, 2017-2018

(K=*Kalong*, MK=*Mora-Kalong*, B= *Beel*, P=*Pukhuri*, Kh=*Khal*, TW=Tube Well, RW=Ring Well, EMP=Electrical Motor Pump, and DWP=Diesel Motor Pump**)**

5.4 Traditional Hydrological Knowledge and Belief Systems

The traditional hydrological knowledge and belief systems of an area are very important and quite interesting in the context of conservation of water and water bodies.. It is because such knowledge, thoughts and beliefs reveal about the hydrological conditions and situations that prevailed in the past. If rain occurs on Saturday then people believe that such rain will be continuing till next Tuesday, and if it rains even on Wednesday then people believe that it will be unending till next Saturday. This continuous rain at least for one week or more is locally known as *satah*. The impact of such beliefs is many people do not germinate rice if it rains on Saturday or Tuesday. Again, if there is scanty rainfall then people used to catch two frogs and marry them. The people believe that by doing so rainfall will occur. People also plough the courtyard of the houses silently without the notice of the house owner. Such activity causes rainfall as believed by the villagers.

In almost all the rural areas, people generally have water phobia regarding some water related ghosts. There are some places in the village where people believed that there exists water ghosts and if people will catch fish there, he will be killed. The most common water ghost is *Baak. Baak* is that kind of ghost which eats all the fish from behind that one carries with him. So, people do not go to such areas either for fishing or to make their cattle drink water. Such areas therefore remain covered with forests and eventually become ecologically very rich. The area becomes rich not only in terms of trees and forests but also in terms of aquatic plants and animals. Water phobia among people has helped in the conservation of the wetland ecology. Fear among people has not given them guts to use the resources in the area.

Chapter VI
PROBLEMS AND PROSPECTS

6.1 Problems

The rural hydrological environment of the Brahmaputra valley has been facing lot of problems due to the changes in nature and human culture. Human beings have long been playing the crucial role in altering the natural settings over the earth's surface at an unprecedented rate (Sievers *et al.*, 2018) by practicing varied set of activities in their day-to-day life while the role of the natural factors in this regard cannot be denied as well (Strahler and Strahler, 2007). The scenario has become gradually very intense with the shifting of people's occupations (Phillips, 1991) from primary to secondary and tertiary sectors (Innes *et al.*, 2013). The disturbed ecosystem has on the other hand, also badly affected the human-environment system (Levin and Clark, 2010; Innes *et al.*, 2013). The processes of modernization, urbanization, industrialization and other socio-economic and cultural transformations have mounted the pace of changes and disturbance in environmental, ecological as well as hydrological processes within the ecosystems. The changes in these processes are inter-related and have ultimately degraded the natural balanced environment that prevailed earlier. It should however be mentioned that the pace of environmental degradation is slower in the rural areas as human intervention on the nature is more in the urbanized areas.

It is noteworthy that micro changes in the hydrological and ecological settings of its components can alter the rural hydrological system of an area, which may in turn pose a number of hydrological or ecological problems creating imbalances in the entire ecosystem. In the last few decades, especially the 1980s, it has been found in the entire Brahmaputra valley that human intervention on the pre-existed settings of the Nature has resulted in a number of micro problems creating macro impacts on both the Nature and humans.

The rural hydrological characteristics of the village have been experiencing remarkable changes during the last few decades because of both natural as well as anthropogenic factors acting upon it. The village however, has numerous wetlands-*pukhuri, khals, nodi, morasuti, hola, pitoni* and *doloni* that play a significant role in maintaining a balance between the rural hydrological conditions and the ecology prevailing in them. The problems that have been going on in the village like fragmentation of wetlands due to the construction of four lane highway, fragmentation of habitats, loss of biodiversity, loss of waterscape, blockade in river water flow by unwise building of road, etc. have disturbed the natural hydrological conditions creating innumerable problems on the other hand. Thus, the relationship between hydrological conditions and ecology that existed earlier with perfect harmony within the village has now been gradually deteriorating with increasing human intervention. The main cause behind this is unwise use of the wetland resources and unplanned construction of roads and other infrastructures.

Similarly, the problems in Kahargaon village have started once people's dependence on the wetlands decreased with time. With the decrease in people's dependence on wetlands, the degradation of the wetlands by building infrastructures on them, filling them up, converting some of them into agricultural lands, etc. have started thereby causing several problems.

With the increase in population in the village, parts of the two *beels* in the village have been converted into ponds by building embankments. The major part of the two *beels* have been converted into *bao* rice fields as the only source of water for these *beels* is rain water and there occurred shrinkages of water levels. As the water level goes down, these *beels* have become suitable for the cultivation of *bao rice.* It should be mentioned here that, though these are locally called *beels* these are actually *pitonis* (marshes) where water level remains very low. With the cultivation of *bao* rice varieties, like *kurmi bao, tora bao*, etc., these two *beels* have gradually lost its originality as they were turned into *baotolis* (*bao* rice fields).

With the construction of Salmara Pam road, the *chuburi* becomes completely flood free which in turn has caused adverse impact on the wetland ecosystems on the one hand and also agricultural production on the other as there is no recharge of water and fertile alluvium deposits in the wetlands and on the paddy fields. . Again, the variability of fish species along with its number has decreased with time. Many of the *baotolis* have been converted into ponds as fishing gives them much profit than *bao* rice.

On the other hand, low water retention in the wetlands during the dry winters has caused another serious problem as scarcity of drinking water prevails in Kolongpar and northern Duboritoli *chuburis*. Similarly, it becomes difficult for the fishes and other aquatic species to survive in those wetlands where water level subsides to less than 2.0 feet. In case of Kolongpar *chuburi*, the water of the Kolong does not retain for long. As soon as the water of Kolong goes down during winter, the water level of the *khals* in the *chuburi* also goes down. During February-March, none of the *khals* has a single drop of water. Therefore, people do not have *pukhuris* in the *chuburi*. Hence, the number of *pukhuris* has not increased in the past few years. However, two *pukhuris* were there for fishing but due to lack of water, the owners do not rear fishes, rather they left it on their own and sometimes catch fishes that have wildly come into them during floods. Even the soils of this *chuburi* are very sandy owing to which growth of vegetables is not much possible in all the areas adjacent to the river hence vegetables are grown only on certain lands.

In *Duboritoli*, some parts of the agricultural lands during summer have been left fallow because of heavy inundation of water on those fields. However, in winter mustard is grown on those lands as during winter water dries up and creates suitable condition for the cultivation of *rabi* crops. As the agriculture of the village is, still dependent on the monsoonal rains, therefore, erratic rain that happens sometimes, cause serious damage to the crop production.

The attack of weeds has been another problem in the wetlands of the village, especially in the Mora-Kolong. The attack of the weeds is more in the Mora-Kolong in comparison to other wetlands of the village. After joining both the ends of the meander of the river Kolong, the water discharge of the channel that is left out or Mora-Kolong has decreased over time as water flows directly following the straight path of the channel. The decreasing water discharge in the Mora-Kolong has resulted in siltation and as a result, the riverbed has risen up. Again in 2012, a road has been constructed over the Mora-Kolong itself with only a pool for the water to flow through and this activity has ultimately stopped the water flow as it carries only little amount of water. Thus due to anthropogenic activities, there has been serious impacts on the Mora-Kolong as water flow has become static now. The static water in the channel with low water level has resulted in the growth of many aquatic plants, shrubs, bushes, creepers and even some trees.

It is important to note that due to static water in the channel and loosing of connection with the main channel i.e. Kolong; there has been decrease in the aquatic species in the wetland. Even the pre-existing ones could not survive in the wetland as they are suffocated by the rapid growth of weeds. On the other hand, if the fishes so available in the channel are once caught, there remains no fish species left in the Mora-Kolong as there has been no influx of fishes to it.

Again, the frequency of floods in the village has also been decreasing in the village. There have been frequent floods in the village, especially before 21st century, which has not been occurred during the recent times because of the disturbance for unwise and unplanned construction of roads. During floods, the water of the Kolong enters the village through Salmara Pam but after the construction of the Salmara Pam road in 1989, it has disturbed the water flow in the village thereby decreasing the intensity of floods. It has on the other hand, affected the natural soil fertility, ground water recharging, and inputs of aquatic animals (especially fishes) to wetlands.

The river, during floods deposits sediments on its banks as well as on the adjacent areas, which helps in enhancing natural soil fertility. It is seen that now a days, there has been increase in the application of chemical fertilizers that causes many diseases to humans and the aquatic species of the adjacent wetlands. Again, it is seen that there has been decrease in the ground water table due to decrease in the frequency of floods, as it is known that floodwater recharges the underground water. Besides, there has been decrease in the species of fishes and other aquatic animals because floodwater does not recharge the ecological settings of the wetlands now a day. As there is decrease in floods, there are no inputs of fishes and other aquatic animals to the *pukhuris*, *khals*, *beels,* etc. Earlier the water of the *Kolong* recharged those wetlands with numerous species of fishes and animals, which enrich the ecological settings of the wetlands in the village. Thus, many aquatic species have now become endangered or even extinct.

It should be noted here that with the construction of the four lane highway over the old two lane highway, many culverts have been removed due to which there has been lots of disturbance in the surface water flow. These unplanned roads constructed in the village ignoring the rural hydrological settings of the village have made fragmentation of ecological niches. The case is much worse in the southeastern part of the village where the ecological habitats of the fishes and other aquatic plants and animals were being detached from the Mora-Kolong. Earlier during the monsoons, the water of the Mora-Kolong enters the southeastern part of the village and thus recharges the *pukhuris* and *khals* with numerous species of aquatic animals. However, after the construction of the four-lane highway, the water of the Mora-Kolong has not entered that part of the village since 2004.

The village has also got some problems related to the sinking of water level of tube wells and ring wells. As the water table goes down during winter, the tube wells cannot pump up the underground water due to which the people have to fetch water from their nearby wetlands. Earlier, people in such a situation generally fetch water from the Kolong and *khals* and as soon as they realized the need of storage of water, they dug up *pukhuris* for fishing in general and handy water facilities in particular. Such case in very common in Kolongpar, Duboritoli and Salmara Pam where the water of the tube wells dry up during February and March. People of Kolongpar therefore, fetch water from the river Kolong when the tube wells are unable to pump up the underground water while the in Duboritoli, some people used the water of Kolong and others used the water of Mora-Kolong. However, as the water of the Mora-Kolong has now become static and the level of the water remains at a low level so; deep burrowing has been done to avail the water facilities. It is interesting to mention that as Salmara Pam is located away from the river Kolong and Mora-Kolong, people earlier had to walk long and fetch water from the Kolong and they also used the water of *khals* but now they have used deep burrowing with the help of which they have access to water facilities.

Another very significant problem in the village is that the numbers of *khals* have been decreasing over time. The number of *khals* before 1990 was 137, which were reduced to 85 *khals* at present with a decrease of -37.96%. Thus, this has become a very problem as the *khals* are the repositories of variety of wild fishes, which maintains its own unique character and ecology. Consequently, many of the species of fishes have become endangered and thus there occurred ecological disequilibrium in the aquatic ecosystem, which in turn has adverse, affects overall ecosystem as well. Due to construction of the four lanes National Highway, many *khals* in the village, especially in its south-eastern corner have been filled up. On the other hand, some of the *khals* in the village has been filled up for construction of houses while some others have been used as dumping grounds.

6.2 Prospects

The rural hydrological environment of the village has contributed immensely towards maintaining and enriching the ecological conditions on the one hand and to sustaining the economic conditions of the villagers on the other. All the wetlands of the village are largely endowed with a range of aquatic floral and faunal species, which have been contributing tremendous roles towards ecological diversity, and economic sustainability of the village. Besides, being the habitats of aquatic flora and fauna and sources of irrigation to the agricultural fields, the wetlands of the village are also related to the culture and traditions of the villagers. The difference in hydrological settings has not only made diverse ecological niches in the village but also differentiated in the cropping pattern and practices, land use pattern and land cover status. Thus, the rural hydrological settings of the village have resulted in the diverse cultural landscapes within the village.

The village has immense potential for developing some of the wetlands into store-houses of fishes and edible vegetables. As the village is endowed with different types of wetlands, so they can be well developed into fisheries with large-scale fish productions. Thus, pisciculture can be well developed in the village, which will not only meet the demand for fish in the village itself and the neighbouring villages but also boost the rural economy

Owing to varying hydrological conditions in the village, the land has immense potential for its diverse use. The fertility of the soils and the hydrological conditions available in the village has helped in the growth of various crops like rice, pulses, edible vegetation, etc. Due to paucity of water in the agricultural fields and lack of irrigation facilities in the dry season, agricultural production and productivity has been hampered a lot. Thus, if proper irrigation facilities can be provided, the lands of the village has immense potential to produce more which will be sufficient to the local demands of the people within the village rather, the farmers will be able to sell them in the market and earn money from it.

Besides, the wetlands of the village have immense potential for the promotion of ecotourism in the area if some of the wetlands are turned into eco-water parks where various water related activities like boating, angling and various other water sports should be introduced. The establishment of such a park will become a spot of tourists' attraction, which will in turn enhance the overall development of the village. However, the main point to be kept in mind while going for developing the area by utilizing the natural beauty of the wetlands is that there should be construction of eco-parks without disturbing the pre-degraded ecological settings of the wetlands. Besides, such parks will generate employment facilities for the locals and help them to engage themselves in various other works related to it. Though water parks should be created in the wetlands, the motive behind such creation should not be commercial; instead, conservation of the wetlands should be given the highest priority. Thus, ecotourism development in the area will ensure two-way benefits of providing employment facilities for the locals on the one hand and conservation of wetlands on the other (Schevens, 2002). It should be noted here that participation of local communities in the wetland resources conservation (Williams, 2002 and Andrade and Rhodes, 2012) with their traditional knowledge, skills and practices can enhance effective conservation meeting the needs of the local people (Trisurat, 2006; Thompson and Choudhury, 2007 and Lamsal *et al.*, 2015).

As it gets difficult to grow vegetables in the village, especially in Kolongpar and Duboritoli during the dry months i.e. February and March, people can opt for waste banana tree trunks to grow vegetables as they do not need watering the vegetables because they contain ample moisture to help the vegetables grow naturally. In this way, eco-farming can be practiced as after harvesting the vegetables, the tree trunks decompose and enrich the soil with nutrients. Thus, the village can mount its production of vegetables even during the dry winter season where there is paucity of water supply.

On the other hand, integrated farming should be practiced in the lowlands where along with cultivating *bao* rice, pisciculture can be carried out. In such a condition, the farmer can gain income from both *bao* rice and fish production. Contrary to this, integrated farming can also be practiced in the *pukhuris,* which will be cost-effective on the one hand and profitable on the other. The integrated fish farming in the *pukhuris* along with the duck houses built on them will enhance fish production as duck droppings directly go into the *pukhuris* (Biswas, 2015) and fishes can consume it directly. Besides, droppings of ducks are good sources of carbon, nitrogen and phosphorus (Biswas, 2015) which helps in the natural growth of the fishes. Poultry manure can be used fresh, or after processing, to enhance natural food production in sun-lit tropical ponds (Little and Satapornvanit, 1996). Fish feeding low in the food web - the carps and tilapias benefit most from this type of management since they can utilize plankton, benthic and detrital food organisms effectively (Little and Satapornvanit, 1996). *Pukhuris* having water depth of 4.92 to 6.56 feet even during the dry season can practice this type of integrated farming (Biswas, 2015).

With growing intervention in the wetlands, many species of aquatic plants those grow in different wetlands of the village have become endangered or extinct and therefore it is high time to conserve them. In order to do so the wetlands having greater potentiality of having different plant species should be upgraded to aquatic botanical gardens that will not only attract tourists but will also provide ample scope for botanical studies and research.

It is important to mention that many fish species, which were found earlier, have become endangered and some others have become extinct in the village. Therefore, it is high time to conserve them. There should be a fresh water fish museum, if not in the village then at least in the district to conserve the endangered fish species of the village as well as of the district otherwise they will become extinct soon.

Chapter VII
SUMMARY AND CONCLUSION

7.1 Summary

Rural hydrological environment simply refers to the surrounding conditions of the rural areas as determined and defined by water. The hydrological conditions of each of its components, viz. *pukhuri*, *khal*, *beel*, *hola*, *pitoni*, *doloni*, *nodi*, *mora-nodi*, low-lying fields etc. are taken into account.

This study can thus, be considered very significant as it unveils the problems of the village related to various hydrological changes that have occurred due to unprecedented and unplanned human activities since 1970s.

The present study is divided into seven chapters, namely- chapter I: introduction, chapter II: the village in the valley, chapter III: status of rural hydrological environment, chapter IV: changes in rural hydrology and utility pattern, chapter, chapter V: rural hydrology and livelihood issues, VI: problems and prospects and the last one is the summary and conclusion.

The introductory chapter includes statement of the problem, objectives, research questions, database and methodology, a brief review of relevant works, organization of the study, local terms and terminology and scope for further research. Though several studies on hydrology have already been done but studies on hydrological environment in a micro-rural setting is still very limited. This work examines the status of and changes in rural hydrological situations and human response to the changing rural hydrological system to sustain their life and livelihoods. Thus, to have profound detail of these aspects, four objectives and four research questions have been formulated. The review of literature is done through some important works done so far in the field of rural wetlands and hydrology, water resources and their utility

The second chapter is an introduction to the geographical background of the village, where location, history, physical characteristics, cultural and socio-economic conditions, etc. are briefly introduced. The village, covering an area of 3.80 sq. kilometers, is located in the southern floodplain of the middle Brahmaputra valley. The village, being located on the bank of the river Kalong, represents typical floodplain characteristics. The village falls in the sub-tropical monsoon region and therefore the village experiences four distinct seasons- premonsoons , monsoon , retreating monsoon, and winter season. The river Kolong, flowing through the northern part of the village forms its northern boundary while the Mora-Kolong forms the eastern boundary of the village. The four-lane National Highway forms the southern boundary of the village which has altered the hydrological as well as ecological conditions of the village. The village is endowed with fertile alluvial soils where variety of agriculture is practiced owing to adjustment with varying field hydrological conditions. The length of the river bordering the village is about 3.7 kilometers approximately. The village is endowed with a large natural as well as man-made wetlands of different shapes and sizes which act as surface storages of water. Thus, pisciculture has become another important activity amongst the people.

The village is a typical Assamese village with 291 households and a total population of 1,374. The density of the village is 362 persons per square kilometers. Agriculture is the main occupation of majority of the people in the village. Along with that, rearing of cows and goats for milk and poultry farming has also enriched the economy of the people. Besides, some people are also engaged in secondary and tertiary activities.

A brief description of the present status of the rural hydrological environment of the village has been discussed in Chapter 3. The inputs and outputs to rural hydrological system; the indigenous typology and evolution of wetlands have been identified and studied in detail. The flood or water levels on different fields, like faringtoli or bam-mat, salitoli and dab-mati in different months of the year have been found out. Again the water level in the *pukhuris*, *khals*, *beel*, Mora-Kolong and Kolong in different *chuburis* of the village has also been found out. The ground water conditions of the village have been simply measured by observing the water level of tube wells and ring wells. Besides, to assess the ecological settings in the wetlands, selected water sample have been tested to find out the water quality of different wetlands. As different hydrological environments give rise to different ecological conditions so, the relationship of the components of rural hydrological environment and ecology has also been discussed in detail.

The changes in rural hydrology and utility pattern have been analyzed in chapter 4. In this chapter, the nature of changes in rural hydrology and utility patterns are discussed. Each and every component of the hydrology of the village has changed to a large extent either due to natural or anthropogenic factors. The changes in the nature of the hydrological system, field and wetland hydrology, water use and their sources and aquatic system, etc. have been analyzed. In addition to that the causes of such changes and their impact on the environment and humans have also been discussed in detail.

The fifth chapter deals with the livelihood issues of man in relation to hydrology. In this context, adoption and interaction of man with different components of rural hydrology have been discussed. Again, human adjustment to varying hydrological situations by changing land use patterns and practices and raising the altar of the houses, etc. have taken up in the village.

Additionally, the functions of wetlands and their contribution to the economy, ecology and culture of the village have also been discussed. The chapter also compares the nature of interaction between man and the wetlands before and after 1970s and also discuses about the land use patterns adjusted to village hydrology. The chapter also deals with the traditional knowledge and belief systems of the people regarding hydrological environment. The role of water phobia in the conservation of the wetland ecology is another important aspect which is discussed in this chapter.

Chapter 6 deals with various problems and prospects of rural hydrological environment in the village. The village has been facing lot of problems due to increasing human intervention in the rural hydrological system and concomitant degradation of the ecohydrological conditions. Besides, the prospects for development of the wetlands in general and the village in particular through proper or wise utilization of its resources have been discussed in the chapter.

7.2 Conclusion

Kahargaon, located in the southern flood plain valley of the river Brahmaputra represents typical rural hydrological characteristics of the valley. The hydrological conditions of the village are to some extent maintained by the proper functioning of the wetlands. Some of the wetlands of the village are natural while some are man-made. The village, being a floodplain one has experienced micro variations in elevations which have given rise to the origin of different surface water storages and field pattern. The villagers have identified as many as eight typology of wetlands, namely 1) *nodi* (river), 2) *pukhuri* (man-made ponds), 3) *khal* (*natural ponds)* 4) *beel* 5) *morasuti* (dead channel), 6) *hola,* 7) *pitoni* and 8) *doloni.*

Until 1826, i.e., before human habitation, the hydrological conditions of the village were governed by natural factors and the surface water flowed according to the natural slope.

The village was inhabited by the *kahars* who settled on the bank of the river Kalong during and after the year 1826. The history of Kahargaon is the history of a confluence of people coming from Teok and Titabar. It was believed that the people fled from these two places because of the invasion of the Burmese. The people from Titabar were originally involved in making bell-metal utensils, so they started up their indigenous occupation in Kahargaon village after their establishment. They continue this occupation upto 70 years before present. However, with the passage of time, this occupation was no longer practiced by the people of the village. People are now engaged in agriculture, animal rearing, fishing, business and various services in government and private sectors.

The river Kolong, flowing through the northern part of the village with its cut-off channel which flows through the eastern part of the village, provides suitable conditions for the development of hydrological environments. As because the village has micro level variations in its relief features, so such micro level variations makes the hydrological situations of the village diverse. These micro variations in elevations have caused the variation in water levels in different field patterns. The water level in the *foringtolis* is almost 1-1.5 ft. while on *salitolis* it is rises up to 2-2.5 ft and remains for almost 5-6 months of the year. Again, the water level of the *dab-matis* is about 3-3.5 ft. Therefore, the villagers have classified their lands as the lands as *faringtoli* or *bam-mati* salitoli and *dab-mati*. The *faringtolis* or *bam-mati* is used for settlement purposes and other constructional activities that contribute towards development of the village cultural landscapes. So, *faringtolis* are used by people for building houses, schools, *namghars*, *masjid*, roads, etc. Again, the *salitolis* are used for agricultural purposes. Rice is the main crop that is cultivated on such lands. Another important variety of winter rice locally known as *bao* is cultivated in the low-lying areas or *dab-mati* where floods and waterlogged conditions make cultivation of other rice difficult (Bhagabati et *al*. 2001).

It is noteworthy that the water supply to the village is met out with the installation of hand pumps by the villagers as convenient source of water. The shallow tube wells for irrigation purpose in the village range from 70-80 ft. deep. The depth of the pipes of the tube wells ranges from 80-140 ft.

Different hydrological environments within the village have given rise to different ecological conditions. Ecological characteristics are not same in all the types of wetlands. The wetlands are the home to different types of aquatic plants and animals, including insects. The ecology that prevails in a river is different from that of a dead channel, swamp, marsh, pond and *beel* because of the difference in their hydrological conditions.

Livelihood pattern of the people is to a large extent dependent on the hydrological conditions of an area. Hydrology of an area in turn, is affected and molded by humans through their activities. Thus, there occurs interaction between the people and the elements of hydrological environment. Interaction was more with ponds as people used water from the ponds for various purposes. Water of the ponds before 1980s was used for drinking, washing clothes and utensils, bathing, soaking of saplings of rice, etc. *Khals* are used for catching wild fishes, edible vegetation, like *makua, kol-mou, helesi,* etc. *Pukhuris* are used for domesticating fishes and consume them according to the need. The Mora-Kolong *is* another source of human interaction. However, with the passage of time, especially after 1980s, the development of water facilities like installation of tube wells and ring wells have deteriorated the interaction between people and the wetlands.

The hydrological conditions of the village have undergone drastic changes. Each and every component of the hydrology of the village has changed to a large extent. The river Kalong which originally flowed from the south-eastern corner, bordering the village in the eastern and northern sides was dug by the government of Assam leaving aside the meander bends in 1970. But it is interesting to note that, due to lack of available arable lands and increase in the number of households, people have started making their settlements even in the winter paddy fields. Again with the increase in the number of human settlements, the number of ponds or *pukhuris* has also been increasing. The lowlands are filled up with soil from other places and built houses there. The *khals* have been filled up for construction of roads. In the name of construction of the four lanes highways, many natural and man-made ponds of the village have already been buried. The wetlands of the village were earlier used by the people for fishing, bathing, washing clothes and utensils, drinking water for themselves and also for their cattle, etc. However, with the onslaught of time, many of such utilizations of the wetlands are rarely seen. Again, people earlier built a bridge of bamboo to connect either side of the *morasuti*. However, people have now replaced this traditional bamboo bridge by making a *kutcha* road with having only a small pool. This has hindered the free movement of various fish and other aquatic species, especially during the summer season.

7.3. Recommendations

Based on the findings and analysis, a few suggestions for the overall development of the village have been mentioned below:

i. The rural hydrological settings should be properly studied and given importance in implementing any type of developmental activities as the hydrological settings are closely linked with the ecological diversity of the village and the economic conditions of the rural people.

ii. The roads constructed within or along the village should have sufficient culverts for the uninterrupted flow of surface water and also for the free movement of aquatic species during summer season.

iii. The wetlands and the rivers within the village should be rejuvenated, reclaimed and restored to make the hydrological environment of the village congenial.

iv. The rain water can be harvested and utilized to minimize the pressure on ground water table and also of the surface water bodies.

v. For designing and implementing the rural development plans and policies the local people should be involved and their traditional knowledge and belief systems should be given importance.

vi. Pools on the way of water flow should be such that the water can easily pass through it without any disturbance. If possible, bridges should be constructed.

vii. Small scale and cottage industry can be developed based on the rural resources and agricultural products which can help in increasing the economic condition of rural people. It can also help the villagers by providing more job opportunities.

viii. The agricultural landscapes are closely associated with wetlands and other landscape components. Thus, application of chemical fertilizers and insecticides affect the wetland ecology. Therefore, the indigenous methods of agricultural practices should be continued to some extent and application of bio fertilizers and organic farming should be encouraged as much as possible.

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APPENDIX 1

Table: Slope analysis using Wentworth's method

Grid no.	Contour interval	No.of contours crossing per grid	$\tan\theta = \frac{N \times I}{L \times 636.1}$	$\theta = \tan^{-1} \frac{N \times I}{L \times 636.1}$
1	4	-	-	-
2	4	10	0.0157	0°53´
3	4	8	0.0125	0°42´
4	4	-	-	-
5	4	-	-	-
6	4	-	-	-
7	4	-	-	-
8	4	-	-	-
9	4	14	0.0220	1°15´
10	4	20	0.0314	1°47´
11	4	20	0.0314	1°47´
12	4	12	0.0188	1°4´
13	4	-	-	-
14	4	-	-	-
15	4	-	-	-
16	4	-	-	-
17	4	20	0.0314	1°47´
18	4	20	0.0314	1°47´
19	4	16	0.0251	1°26´
20	4	14	0.0220	1°15´
21	4	12	0.0188	1°4´
22	4	10	0.0157	0°53´
23	4	-	-	-
24	4	-	-	-
25	4	20	0.0314	1°47´
26	4	20	0.0314	1°47´
27	4	18	0.0282	1°36´
28	4	14	0.0220	1°15´

29	4	18	0.0282	1°36
30	4	12	0.0188	1°4´
31	4	-	-	-
32	4	-	-	-
33	4	10	0.0157	0°53´
34	4	16	0.0251	1°26´
35	4	18	0.0282	1°36
36	4	16	0.0251	1°26´
37	4	18	0.0282	1°36
38	4	18	0.0282	1°36
39	4	14	0.0220	1°15´
40	4	-	-	-
41	4	-	-	-
42	4	-	-	-
43	4	-	-	-
44	4	2	0.0031	0°10´
45	4	12	0.0188	1°4´
46	4	14	0.0220	1°15´
47	4	12	0.0188	1°4´
48	4	-	-	-
49	4	-	-	-
50	4	-	-	-
51	4	-	-	-
52	4	-	-	-
53	4	-	-	-
54	4	10	0.0157	0°53´
55	4	12	0.0188	1°4´
56	4	12	0.0188	1°4´

Appendix 2

Table: *Chuburi*-wise changes in water uses over time

Years	*Chuburis*	Use of Water by Households for Different Purposes						
		Drinking	Bathing	Washing Clothes	Washing Utensils	Agriculture	Drinking Water for Cattles	Soaking
Before 1950s	Kalongpar	*K=20, , Kh*=5	K=22, Kh=4	K=20, Kh=0	K=20, Kh=4	K=6, Kh=15	K=20, Kh=4	K= 5, Kh=13
	Duboritoli	K= 35, Kh= 37,	K=35, Kh=21,	K=38, Kh=15	K=35, Kh=17	K=25, Kh=24	K=35, Kh=12	K=8, Kh=28
	Garhmaj	K=0, Kh=45	K=0, Kh=48	K=0, Kh=40	K=0, Kh=46	K=0, Kh=48	K=0, Kh=48	K=0, Kh=49
	Dighaliati	K=14, Kh=0	K=14, Kh=0	K=14, Kh=0	K=14, Kh=0	K=2, Kh=0	K=5, Kh=4	K=3, Kh=11
1950-1970	Kalongpar	*K=20, P=2, Kh=3*	K=20, P=4, Kh=3	K=20, P=0, Kh=0	K=20, P=3, Kh=0	K=9, P=8, Kh=9	K=20, P=3, Kh=3	K=7, P=3, Kh=14
	Duboritoli	K= 35, P= 9, Kh= 11, TW= 3	K= 35, P= 21, Kh= 11, TW= 3	K=38, P= 24, Kh= 6, TW= 3	K=34, P= 23, Kh=14, TW=8	K= 22, P= 9, Kh= 19, TW= 0	K= 35, P= 9, Kh= 3, TW= 0	K= 19, P= 12, Kh= 18
	Salmara Pam	K=0, B=2, Kh=4, TW=0	K=0, B=4, Kh=4 TW=0	K=4, B=2, Kh=4 TW=0	K=0, B=4, Kh=4, TW=0	K=0, B=4, Kh=4 TW=0	K=0, B=4, Kh=4 TW=0	K=0, B=4, Kh=4 TW=0
	Garhmaj	K=0, P=13, Kh=10, TW=2	K=0, P= 45, Kh= 6, TW=2	K=0, P=45, Kh=2, TW=0	K=0, P=32, Kh=11, TW=2	K=0, P=11, Kh=39, TW=0	K=0, P=6, Kh=41, TW=0	K=0, P=19, Kh=45, TW=0
	Dighaliat	K=12,	K=11,	K=13,	K=12,	K=2,	K=5,	K=0,

	i	P=0, Kh=0, TW=3, RW= 2	P=0, Kh=0, TW=2, RW=2	P=0, Kh=0, TW=3, RW=2	P=0, Kh=0, TW=3, RW= 2	P=0, Kh=0, TW=0, RW=0	P=9, Kh=3, TW=2, RW=1	P=9, Kh=6, TW=0, RW=0
1970-1990	**Kalongpar**	P=2, K=20, Kh= 3	P=0, K=25, Kh=0	P=0, K=25, Kh=0	P=3, K=22, Kh=0	P=6, K=12, Kh=9	P=0, K=25, Kh=0	P=9, K=8, Kh=16
	Duboritoli	K=40, MK=10, P=25, Kh=3, TW=5, RW=10	K=43, MK=8, P=6, Kh=1, TW=8, RW=12	K=45, MK= 10, P=3, Kh=0, TW=6, RW=10	K=14, MK=8, P=18, Kh=11, TW=8, RW=12	K=23, MK=12, P=2, Kh=10, TW=0, RW=0	K=28, MK=12, P=3, Kh=6, TW=2, RW=3	K=3, MK=23, P=8, Kh=19, TW=0, RW=0
	Salmara Pam	P=3, Kh=0, B=0, TW=4	P=5, Kh=0, B=0, TW=4	P=4, Kh=2, B=0, TW=4	P=4, Kh=2, B=2, TW=2	P=4, Kh=2, B=3, TW=0	P=2, Kh=2, B=6, TW=0	P=2, Kh=3, B=4, TW=0
	Garhmaj	P=11, Kh=0, TW=18, RW=22	P=16, Kh=0, TW=15, RW=20	P=17, Kh=0, TW=14, RW=20	P=14, Kh=0, TW=15, RW=22	P=30, Kh=21, TW=0, RW=0	P=39, Kh=0, TW=9, RW= 9	P=24, Kh=36, TW=0, RW=0
	Dighaliati	P=0, Kh=0, MK=8, TW=8, RW=2	P=0, Kh=0, MK=5, TW=11, RW=2	P=0, Kh=0, MK=5, TW=11, RW=2	P=0, Kh=0, MK=5, TW=11, RW=2	P=0, Kh=0, MK=0, TW=0, RW=0	P=0, Kh=0, MK=5, TW=7, RW=4	P=5, Kh=9, MK=4, TW=0, RW=0
1990-2010	**Kalongpar**	K=10, P=0, Kh=0, TW=13	K=9, P=0, Kh=0, TW=24	K=12, P=0, Kh=0, TW=11	K=7, P=0, Kh=0, TW=26	K=16, P=2, Kh=9, TW=6 DWP=3	K=11, P=0, Kh=0, TW=13	K=3, P=5, Kh=25, TW=0
	Duboritoli	K=12, MK=10,	K=15, MK=14,	K=16, MK=16,	K=10, MK=7,	K=4, MK=9,	K=9, MK=12,	K=2 MK=14,

		P=8, Kh=0, TW=40, RW=12, EMP=2	P=5, Kh=0, TW=36, RW=10, EMP=2	P=2, Kh=0, TW=32, RW=10, EMP=2	P=7, Kh=4, TW=45, RW=16, EMP=2	P=10, Kh=16, TW=9, RW=0 DWP=8	P=8, Kh=16, TW=13, RW=8, EMP=0	P=18, Kh=47, TW=0, RW=0
	Salmara Pam	P=4, Kh=2, B=0, TW=7, RW=5	P=5, Kh=3, B=2, TW=9, RW=6	P=7, Kh=2, B=3, TW=7, RW=6	P=7, Kh=5, B=0, TW=5, RW=4	P=3, Kh=4, B=6, TW=2, RW=0, DWP=0	P=3, Kh=5, B=5, TW=4, RW=3	P=2, Kh=3, B=15, TW=0, RW=0
	Garhmaj	K=0, MK=0, P=12, K=3, TW=30, RW=20, EMP=2	K=0, MK=0, P=16, Kh=3, TW=29, RW=23, EMP=2	K=0, MK=0, P=14, Kh=3, TW=27, RW=27, EMP=2	K=0, MK=0, P=10, Kh=5, TW=30, RW=23, EMP=2	K=0, MK=0, P=11, Kh=26, TW=12, RW=0 DWP=12	K=0, MK=0, P=14, Kh=23, TW=21, RW=13, EMP=0	K=0, MK=0, P=24, Kh=36, TW=0, RW=0
	Dighaliati	P=0, Kh=0, MK=5, TW=15, RW=4, EMP=6	P=0, Kh=0, MK=5, TW=15, RW=4, EMP=6	P=0, Kh=0, MK=8, TW=15, RW=4, EMP=6	P=0, Kh=0, MK=5, TW=15, RW=4, EMP=6	P=0, Kh=0, MK=0, TW=0, RW=0, EMP=0, DWP=0	P=0, Kh=0, MK=7, TW=13, RW=6, EMP=6	P=4, Kh=2, MK=2, TW=0, RW=0
2010-2017	**Kalongpar**	K=0, P=0, Kh=0, TW=32, RW=5, EMP=1	K=7, P=0, Kh=0, TW=32, RW=5, EMP=1	K=10, P=0, Kh=0, TW=32, RW=5, EMP=1	K=2, P=0, Kh=0, TW=32, RW=5, EMP=1	K=16, P=2, Kh=8, TW=7, RW=0 EMP=0 DWP=4	K=11, P=0, Kh=0, TW=13, RW=7, EMP=1	K=3, P=15, Kh=15, TW=0 RW=0

	Duborito li	K=2, MK=0,P =0, Kh=0 TW=62, RW=0, EMP=7	K=5, MK=4, P=2, Kh=0, TW=62, RW=0, EMP=7	K=4, MK=3, P=2, Kh=0, TW=62, RW=0, EMP=7	K=0, MK=0, P=0, Kh=0, TW=62, RW=2, EMP=7	K=2, MK=3, P=8, Kh=16, TW=14, RW=0, EMP=0 DWP=1 2	K=6, MK=7, P=7, Kh=21, TW=33, RW=2, EMP=7	K=2 MK=14, P=28, Kh=37, TW=0, RW=0
	Salmara Pam	P=0, Kh=0, B=0, TW=16, RW=0 EMP=1	P=0, Kh=0, B=0, TW=16, RW=0, EMP=1	P=0, Kh=0, B=0, TW=16, RW=0, EMP=1	P=0, Kh=0, B=0, TW=16, RW=0, EMP=1	P=3, Kh=4, B=6, TW=0, RW=0, EMP=0 DWP=0	P=3, Kh=4, B=5, TW=4, RW=0, EMP=1	P=2, Kh=3, B=15, TW=0, RW=0, EMP=0
	Garhmaj	K=0, MK=0, P=0, Kh=0, TW=66, RW=0, EMP=8	K=0, MK=0, P=2, Kh=0, TW=72, RW=0, EMP=8	K=0, MK=0, P=1, Kh=0, TW=72, RW=0, EMP=8	K=0, MK=0, P=0, Kh=0, TW=73, RW=0, EMP=8	K=0, MK=0, P=11, Kh=26, TW=13, RW=0, EMP=0, DWP=1 5	K=0, MK=0, P=14, Kh=23, TW=21, RW=0, EMP=8	K=0, MK=0, P=24, Kh=36, TW=0, RW=0
	Dighaliat i	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=1 4	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14	K=0, MK=0, P=0, Kh=0, TW=0, RW=0, EMP=0 DWP=0	K=0, MK=0, P=0, Kh=0, TW=24, RW=0, EMP=14	K=0, MK=2, P=4, Kh=0, TW=0, RW=0, EMP=0

Source: Field Survey, 2017-2018

(K=*Kalong*, MK=*Mora-Kalong*, B= *Beel*, P=*Pukhuri*, Kh=*Khal*, TW=Tube Well, RW=Ring Well, EMP=Electric Motor Pump, and DWP=Diesel Motor Pump**)**

Appendix 3

Bench Mark Survey of Wetland-ecosystem on Kahargaon Village, Nagaon District, Assam

December-January, 2018

1)Name: **2) Age:** **3) Sex**

4) Name of Chuburi:

5) Wetlands:

a)

Pond/ khal	Origin	Year of origin	purpose of occurrence	Area(bigha/ katha)	Shape *	Depth (ft)		Location	Distance from home(mt /ft)	Source of Water
						In summer	In winter			
	Natural/ artificial									
	Natural/ artificial									
	Natural/ artificial									

	Natural/ artificial									
	Natural/ artificial									
	Natural/ artificial									

N.B: Type: rectangular, square, rounded etc.; Location: *Bastimati*, ahu toil, Sali toil, Etc.; Water quality: through chemical test; Soil quality: through soil test

b)

Pond/ khal	**Origin**	**Name of fish**	**Name of aquatic plant**	**Name of aquatic animals/birds**	**Expenditure**			**Fish product-ion in 2017**	**Inco-me in 2017**	**Fishing method**		**Frequency of fishing**
					Fish-seed	**Fertilizer**	**Medi-cine**			**Leasing**	**selling**	
	Natural/ artificial											
	Natural/ artificial											
	Natural/ artificial											
	Natural/ artificial											
	Natural/ artificial											
	Natural/ artificial											

c) Management of Wetlands:

Name of food, fertilizer, medicine	Bank use	Any other

i) What measures you have taken to protect your wetland from thieves?

ii) Land Use pattern on the banks of the wetlands:

d) Utility:

i)

Origin	Live stock/ bird	Dumpi ng of waste	Drinki ng water	So aki ng	Bath ing	Washing	Fishin g	Irrigati on	Religio us / festival

	domesticated		for man/animals			cloth	Cattle	jute	Other			
Natural/artificial												
Natural/artificial												
Natural/artificial												
Natural/artificial												
Natural/artificial												
Natural/artificial												

ii) Tube well and Ring well

Source of Drinking Water at present	Year of Establishment of Source	Water level		Own/sharing	Source of drinking water in the past (approx.. year)	Own source of water in the past?	Distance from Home	Methods of water harvesting	Methods of storing drinking water in past
		In Summer	In Winter						

6) Public pond/beel:

a) Pond/Beel

Name of the Chuba (stack holder):

Name of the pond/beel:

Year of origin:

Type of the pond: Natural or manmade.

Reasons behind the origin of the pond:

Location of the pond:

Distance from the chuba:

Size of the pond (in ft):

Water level (in ft) of the pond in winter season and summer season:

Kind of fish available in the pond:

Kind of aquatic plants:

Kind of aquatic animals/ birds:

Fish production in the year 2017:

Money income from the pond in the 2017:

Water quality (through chemical test):

Soil (bottom) quality (through soil test):

b) Dead/abandoned Channel:

Name of the Death Channel:

Source and destination of the Death Channel:

Distance of the death Channel in the chuba (in ft/mts):

Average width:

Kind of fish:

Kind of aquatic plants:

Kind of aquatic animals:

Name of the Chuba crossed by the channel:

Level of water in summer and winter seasons (in ft/ mts):

Water quality (through chemical test):

Soil (bottom) quality (through soil test):

c) Others:

7) Have you observed any kind of change in the last 10 years?

8) Do you have any kind of future plan regarding your wetland?

9) Agriculture:

No. of Agricultural Plot	Type	Source of Irrigation	Flood Level (m/ft)		Cropping Pattern	Present Land Use	Past Land Use	Cause of LU Change	Associated Wetland (if any)
			In Summer	In Winter					

N.B. - Type: Ahu, Sali, Bao. Etc. **Cropping Pattern**: Mono Cropping, Multiple Cropping

10) What do you think of the impact of wetlands on your agriculture?