# IRRIGATION DEVELOPMENT IN ASSAM:
# A STUDY ON UTILISATION AND SEASONAL VARIATIONS

**A THESIS SUBMITTED TO THE UNIVERSITY OF HYDERABAD IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF**

**DOCTOR OF PHILOSOPHY**

**IN**

**ECONOMICS**

**By**

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**NOVEMBER 2015**

In Memory of

My

Beloved Father

(Lt. Sobendra Narzary)

# DECLARATION

I, **Devonath Narzary**, hereby declare that this thesis entitled, **"Irrigation Development in Assam: A Study on Utilisation and Seasonal Variations"** submitted by me under the guidance and supervision of **Dr. Phanindra Goyari,** is my bona fide research work which is also free from plagiarism.

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# CERTIFICATE

This is to certify that the thesis entitled "**Irrigation Development in Assam: A Study on Utilisation and Seasonal Variations"** submitted by **DEVONATH NARZARY** bearing Regd. No. **08SEPH 11** in partial fulfillments of the requirements for the award of Doctor of Philosophy in Economics is a bona fide work carried out by him under my supervision and guidance which is a plagiarism free thesis.

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*Devonath Narzary*

# CONTENTS

## List of Tables

List of Figures



**List of Abbreviations**

| | |
|---|---|
| ASEB | Assam State Electricity Board |
| AIBP | Accelerated Irrigation Benefit Programme |
| ARIASP | Assam Rural Infrastructure and Agricultural Services Project |
| ASMIDC | Assam State Minor Irrigation Development Corporation |
| BTAD | Bodoland Territorial Area Districts |
| BRPL | Bongaigaon Refinery Petro Chemical Limited |
| CMIE | Centre For Monitoring Indian Economy |
| DAPRD | Department of Agriculture and Panchayat and Rural Development |
| DW | Dugwell |
| DTW | Deep Tubewell |
| GCA | Gross Cropped Area |
| GIA | Gross Irrigated Area |
| HYV | High Yielding Variety |
| NER | North Eastern Regional |
| NGOs | Non-Governmental Organizations |
| NH | National Highway |
| N+P+K | Nitrogen Phosphorus Potassium |
| NSSO | National Sample Survey Organization |
| NSA | Net sown Area |
| NSS | National Sample Survey |
| STs | Scheduled Tribes |
| SCs | Scheduled Castes |
| SKY | Samriddha Krishik Yojana |
| STW | Shallow Tube well |

## Abstract

This thesis examines the development of irrigation and impact of irrigation on the seasonal variations of productivity of paddy crop in Assam. The main objectives of this thesis are (i) to analyze the structure and growth of irrigation development in Assam, (ii) to examine the availability and utilization of created irrigation in the sample villages with the help of primary field survey data and (iii) to examine the impact of irrigation on the seasonal paddy yield variations in the sample. Both primary and secondary have been used in the present study. The primary data were collected through field surveys in ten villages of Chirang district of Assam with the help of structured survey form.

The study found that rainfall and naturally flow waterways are the main sources of irrigation for paddy cultivation in the sample region. Out of total gross cropped area only 43.9 percent area under paddy cultivation were irrigated in the combined sample regions. About 50.6 percent of total areas under paddy cultivation were irrigated by naturally flowing waterways. Although, sample farmers used modern irrigation equipments such as pumpsets, borewells, and tubewells, irrigated areas under those equipments were low. Sample farmers cultivated paddy in all three seasons of the year. The yield of summer paddy was found to be the highest compared to the winter and autumn paddy. The yield response function of rice yield was estimated by specifying the double log linear multiple regression model. The estimated results of the impact of irrigation, HYVs and fertilizer on the yield of rice was found to be positive and significant in explaining the variation of paddy yield in the sample during study period. The study suggested that minor irrigation in the sample regions can be increased with proper co-ordination of concerned government offices, extension workers and sample farmers (who are the main users of irrigation facilities).

# Chapter 1
# Introduction

## 1.1 Introduction

Irrigation, which is defined as the artificial supply of water or application of water by human agency to assist the growth of crops, grass, plants and trees, is the most important factor of production and it affects productivity of any crop. The main function of irrigation is to moderate the impact of irregular, uneven and inadequate rainfall and prevents serious and semi-famine condition after years of droughts. Thus, provision of assuring and adequate artificial water supply on time during the entire crop- growing season is very much essential. This would be possible only through the creation of artificial irrigation without dependence on rainfall which is very uncertain. Artificial irrigation generally guarantees adequate, assured and timely supply of water and ensures stability in the field of agriculture. According to Singh (1962), artificial irrigation has been the best solution for stability, high crop intensity and increased crop yields in Indian agriculture. Hence, irrigation serves as one of the primary and precious inputs of production.

In addition, irrigation lessens the high instability in area, output and yield of rain-fed farming. This is evident from the studies like Dhawan (1988) and Rao et al. (1988). According to their studies, irrigation has positive impact in stabilising farm output. Thus, the importance of irrigation stems from the need to stabilise and to step up the quantum of agricultural output to meet the mounting food demands of the fast growing population. Stability in agriculture encourages the use of more fertilisers, pesticides, high yielding variety seeds, changes in the cropping pattern from inferior food crops to superior food and commercial crops which are more economical in terms of farm income and also absorbs more labour. This result helps to substantial increase in farm productivity and enhances the income of the farm households. Hence, it induces to invest more in irrigated agriculture. White (1978) correctly pointed out that a successful irrigation system can improve the well-being of rural households through abundant and widely distributed water supply, better nutrition, better housing, better health care and increased standard of living. He further observed that a sound and appropriate irrigation system will lead to an overall transformation of the rural sector through increased farm production, per capita income, generation of additional employment opportunities and enhanced wage rates. As a result, it helps to reduce the intensity of rural unemployment and under employment and thereby it improves the standard of living of the rural masses.

Apart from stabilising role, irrigation is assumed to have high role in the context of new technology adoption, where high yielding varieties and multiple cropping are being practiced (Dutta 2011). The shift from traditional cropping pattern to multiple cropping is possible only where there is provision of available irrigation facilities. A study by Neog (1980) observed that after the commencement of an irrigation project, HYV rice and improved techniques made considerable impact on farm income and encouraged the farmers to adopt double cropping with the introduction of HYV seeds in the command area. Verma (2007) rightly assessed the importance of irrigation in the development of Indian agriculture and suggested that conservation and supply of water should be the first measures that may be adopted to increase the area under crops and increase productivity per unit of land. Accordingly, the main objective of the government should be an augmentation of agricultural productivity and creation of more employment opportunities. In the process, irrigation has been found to be the most important factor in augmenting both agricultural output and employment opportunities in agriculture sector. According to Gowda (1989), irrigation introduces a factor of stability in agriculture and saves the farmers from uncertainty, anxiety and tension over the prospect of the failure of crops in the years of inadequate or too early rainfall. Besides, irrigation plays a dominant role in the development of allied activities such as animal husbandry, fishery, poultry, etc. and agro-based rural small scale and cottage industries through adequate supply of raw materials. Thus, irrigation plays an important role in overall development of any economy in general and agriculture sector in particular.

## 1.2 Previous studies

There are ample studies on irrigation development and its impact on crop productivity and productivity variations within the country and around the world. Most studies were concerned with identifying the factors influencing irrigation development, whereas some studies suggested several factors which are responsible for poor irrigation development and utilisation. Moreover, there are vast studies in the literature on the impact of irrigation on crop production and productivity. Accordingly, they have presented the positive and significant impact of irrigation on crop production and productivity, utilisation of fertiliser, cropping intensity, adoption of HYV seed, etc. and recommended policy suggestions for the improvement/development of irrigation sector. Thus, in this section an attempt has been made to review some studies which are relevant to the present work.

### 1.2.1 Problems of Irrigation Development

Some of the major factors that affect the development of irrigation are economic factors, technical problems, institutional and management problems.

Although, Assam is blessed with abundant rainfall and groundwater resources, the agricultural sector still faces the problem of water shortage for cultivation. Due to lack of systematic irrigation facilities in the state, more than 50 percent gross cropped areas are served by rainwater alone. Lack of interest of the concerned department, mismanagement of irrigation, lack of awareness, economic conditions are some of the main factors which affect the irrigation development. Moreover, the created irrigation facilities are also not being utilized properly owing to many factors.

David (1990) attempted to examine the irrigation development and factors responsible for the poor irrigation development in the Philippines. The study found that the irrigation development in the Philippines was only 47 percent during the study period which is quite less. Thus, he tried to examine the various possible factors which affect the irrigation development in the Philippines and found that lack of coordination between the distributors and beneficiates, insufficient fund to construct channels to distribute water in the fields are the main factors which affect the development of irrigation.

Baxter and Arun (1999) analysed the main problems faced in the development of irrigation in India. The study observed that physical constraints like inadequate maintenance, resulting in the progressive deterioration of the surface irrigation system and power, water management due to the ineffective control structure for surface irrigation and inappropriate incentives for groundwater use are the main factors that influence the irrigation development. Sukla and Gurjar (1990) found that lack of proper management and distribution of irrigation was the main problem of irrigation development. According to them, improper management led to unequal distribution of canal irrigation project. In their survey, out of total sample farmers, only 60 percent of farmers who were in head position benefited from canal irrigation. Remaining 40 percent located at the lower reach did not get the opportunity of canal irrigation. Thus, only farmers who were at the upper reach could use modern farm inputs for the crop cultivation and reaped higher productivity. Owing to the poor management, there was an improper distribution of irrigation among the different sections of the farmers. Thus, they conclude that proper management along with the proper adoption of irrigation facilities is very much important for a successful irrigation development.

Palanisami (1984) argued that the water management is one of the major factors that determine the performance of canal irrigation in India. According to him, although there was a tremendous investment in irrigation sector by installing a canal irrigation system, the performance of canal irrigation was found to be very poor. The main reason observed by him was the mismanagement of irrigation system. The management of irrigation system is found to be neglected. Owing to this, the cost of construction of was swelling, the construction sites were exhausted, arouse disputes over sharing water rights between neighbouring states, etc. As a result of these constraints, the viability of irrigation system reduced tremendously and the performance of the irrigation sector became gloomy in the country.

Cornish (1998) portrayed the factors with the greatest influence on the modern irrigation systems on items such as availability of water, types of exploitation, farming system, the role of government and private sector agencies, marketing and finance that attributes the attitudes of the farmers to use the irrigation systems. He furthermore states that economic factors are the foremost effective elements for attracting farmers to use of new irrigation systems.

Sukla and Gurjar (1990) made an attempt to examine the factors responsible for the failure of many irrigation projects in the country. According to them, mismanagement, lack of coordination between providers and beneficiaries, lack of technical soundness and economic feasibility are the major problems that affect the success of projects. Among all these factors, lack of proper management is the main factor which led to the failure of many irrigation projects. Therefore, they suggested for the effective management of irrigation for better utilization of available irrigation facilities.

Gholamrezai et al. (2014) made an attempt to examine the factors affecting the adoption of the new irrigation system in Iran. According to them, well designed, well properly installed, well operated and well maintained irrigation system influence the adoption of modern irrigation systems in Iran. Constant increasing awareness is needed for farmers to encourage in adoption of new irrigation methods. The study found that five factors like economics, social, support, individual and environmental factor encourage the farmer to use of the irrigation system.

Similarly, study of Mitra (1997) found that the irrigation sector of the country is suffering from many hurdles. As a result, the performance of irrigation sector is always fragile. Moreover, he observed that, sheer neglect of financial parameters of the concerned authority is the main reason for steadily declining in the performance of existing irrigation systems. The study further revealed that minor irrigation is still playing a major role in providing irrigation in the country. On the other hand, the major and medium irrigation systems showed dismal performances. The main reason for the gloomy performance of the major and medium irrigation systems is due to the paucity of funds and low water rates. Thus, the author suggested that political organization and other coordination of managements should takes part in building the irrigation system without any negligence.

The study of Chambers (1992) observed that proper allocation, scheduling and delivery of the water system are major factors for the success of any irrigation project. The management of water includes planning, decision-making, operation of controls and communication, both upward to managers and downward to groups of farmers is very much important for the success of any irrigation project. According to him, for a successful irrigation project, the management must manage in such a way that there must not be any gap between provider and receiver. In other words, there should be full cooperation between providers and receivers.

Bhingraj (1987) studied how improper management of irrigation leads to unequal distribution of irrigation among the different group of farmers. His study showed that, land area on top end farmers received abundant irrigation water and tail end farmers hardly received any water to irrigate their crops. He argued that in majority of irrigation projects, the common problem is deprivation of tail end farmers. Generally, the tail end farmers are always deprived out of irrigation in any irrigation project. The top end farmers always harvest the benefit of any irrigation projects which is reflected in the yields, cropping intensity and water supply. This improper distribution of irrigation is not only wasting the water resources, but also reduced the water utilization of tail end farmers. As a result, the tail end farmers are not able to fully utilize their holdings.

Viswanathan (2010) made an attempt to analyse the performance of irrigation sector and to examine the factors responsible for the poor performance of irrigation system in Kerala. Although the state has abundant water facilities, the problem of irrigation still persists in the state of Kerala. The presence of irrigation system has never been a motivating factor to make their crop choices accordingly. Effective demand for water is lacking by farmers even though there is plenty of water. Thus, the author tries to examine the factors related to the dismal performance of the irrigation sector in the state. The study found several economic and social factors for which the state fails in major irrigation projects. Some of these factors are lack of interest in labour intensiveness in farming operations and relegation of the status of farming to a secondary activity. In addition, sociological reasons such as the growing share of elderly among the farmers as well as labourers also affect the irrigation sector. He further observed that some technical constraints such as the design of the projects, inflexibility of water distribution network and decaying of the irrigation infrastructure are problems in the irrigation sector.

### 1.2.2 Under-utilisation of Irrigation

In many states and regions, an important problem is with the under-utilisation of already created and available irrigation facilities. For example, according to the data given by the office of the chief engineer of the irrigation department in the government of Assam, out of the total potential irrigation created of 673298 hectares, only 157685 hectares (about 23.42%) were utilised in 2011-13. This implies that the created irrigation facilities are not being utilised properly or there is under-utilisation of created irrigation in the state. Generally, in olden days, almost all farmers were dependent on natural water ways for cultivation. It was during 1980s, the concept of irrigation was popularised. Thus, many farmers were not aware of irrigation system and hence the irrigation projects or system failed to attract farmers. Beside this, there are many other reasons for under-utilisation of irrigation system. This gap can happen for many reasons like lack of awareness among farmers, information gap between provider and receiver, improper maintenance of canals and water channels etc. There are many studies existing in the literature who have given various reasons for under-utilisation of creating irrigation in the economy. Some of these studies are Easter (1974), Puttaswamaiah (1977), Pant (1981), Dutta and Chang (1986), Gohain and Gogoi (1986), Bhingraj (1987), Gogoi (1989), Yousuf (1990) and Srinivasmurthy (1990).

The study of Puttawamaiah (1977) found that lack of proper channels and lack of construction of water distributaries are the major problems faced by many irrigation projects. The ultimate result is underutilisation of created irrigation facilities. Among these various factors, two main factors are channels and lack of construction of water distributaries. Generally, in the initial stage of irrigation projects, there are no field channels to serve the particular area. Besides, there is no enough water supply due to lack of water distributaries and sub-distributors. As a result, many fields starve for irrigation. On the other hand, the construction of roads and path connectivity along with construction of water distributaries is also necessary. Thus, non completion of ground works such as land development like levelling and bunding of the areas hinders the utilisation of creating irrigation facilities. Similarly, Chandrasekharan et al. (2004) studied the reasons for underutilisation of irrigation projects and also to examine the performance of irrigation projects. In their study, they found several reasons for underutilisation of irrigation system in the country. Some of these factors are (i) absence of mechanical maintenance, (ii) lack of proper maintenance, (iii) improper distribution of water, (iv) lack of coordination among various departments, (v) irregular supply of electricity, (vi) lack of involvement of farmer community in the management etc. These factors, individually and as a whole together affect the utilisation of irrigation. According to them, the creation of irrigation schemes is not sufficient for the proper utilisation of irrigation, but proper maintenance is a necessary condition for full utilisation of irrigation. They further observed that lack of proper maintenance of canals for long years has resulted in damages and broken canals leading to leakages of water.

The report of programme evaluation organisation of planning commission on the accelerated irrigation benefits programme (AIBP, 2010) also found some problems which prevail on the non-completion of the designed irrigation potential. Owing to problems in land acquisition, lack of coordination among different departments of the state government, labour problems and construction of railway and road etc., law and order problem particularly in the selected irrigation projects, irrigation creation and utilisation is lagging behind. The report suggests that releasing timely fund, mechanism to develop attitudes of the farmers increment of adequate number of technical experts legalize lift irrigation into main canal irrigation mechanism to develop proper coordination between government department and land development department, policy needs to make farmers to adopt appropriate cropping pattern for optimum use of water and financial power for irrigation officials are much needed concerns.

Pant (1981) made an attempt to study the factors responsible for underutilisation of potential created irrigation. The author did a case study on Kosi irrigation project in Bihar. The study found that the main factor for underutilisation of irrigation is due to the fault of the organisation system. He argued that the inefficient management of irrigation project is the main reason for existing gap between creation and utilisation of irrigation facilities. The author further argued that lack of cooperation among the bureaucracy and beneficiary, non completion of residual work, faulty design of outlets and canals etc. are the major factors responsible for underutilisation of created irrigation facilities.

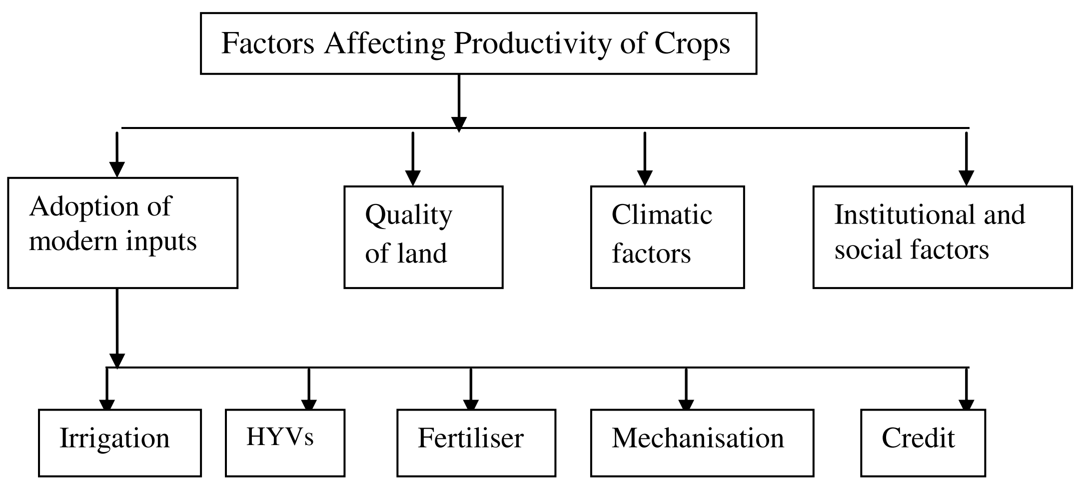
Kalamkar (2011) found that there is under utilisation of creating irrigation potential in Maharashtra. “Out of total 5.29 million hectares of created irrigation, only 38.05 percent (2.01 mha) was utilised in 2006-07”. The study further observed that the inadequate availability of funds for developing hardware aspects of irrigation such as construction of main canals and distribution systems is often cited as the main factors for low utilisation rate of created irrigation facilities in the state.

The study of Srinivasmurthy (1990) found that there are ample factors that affect the utilisation of irrigation. The underutilisation of creating irrigation potential is found more in medium and major irrigation projects as compared to minor irrigation projects. The main reason is the delay in construction of feeder canals and the channels which are required to take water from the main canals to the cultivated lands. Thus, simultaneous construction of feeder canals and necessary land development works along with the construction of main canals could help with performance of irrigation projects better and hence, reduce the problem of underutilisation of creating irrigation potential. The study further found that, the utilisation of irrigation not only depends on the supply side but from demand side also. According to the author, utilisation of irrigation also depends on the adaptability of the farmers to the modern methods of farming.

Dutta (2011) has examined the importance of irrigation in agricultural development in Assam and factors responsible for underutilisation of irrigation facilities. According to him, the problem for underutilisation of potential created irrigation was mostly from supply side rather than demand side. The study observed that lack of maintenance, lack of coordination between various agencies such as different wings of irrigation department, state electricity board, faulty design of canals, etc. are found to create problems in achieving fuller utilisation of irrigation potential in some parts of command areas. In a similar study, Gogoi (1989) made an attempt to examine various factors responsible for the underutilisation of potential created irrigation in the state of Assam. The study found that insufficient agricultural extension facilities and lack of coordination among various departments in the development of irrigation are some factors which hinder the utilisation of created irrigation. The study further observed that the frequent breakdown of the wells, irregular supply of electricity and lack of proper time schedule is also responsible factors for underutilisation of irrigation.

### 1.2.3 Factors Responsible for Low Productivity of Paddy

There are various factors which affect the productivity of rice, assured irrigation facility being an important one. Besides irrigation, factors such as adoption of modern inputs such as HYV seeds and fertilizers, quality of land, climatic conditions, institutional and social factors are the most important factors which affect the productivity of rice in any region or country. Some factors are listed in the diagram below. A number of previous studies observed that there is positive impact of adoption of new agricultural technologies, including assured irrigation and good quality of the land, etc. on the productivity of crops.



**(a) Studies on Impact of Irrigation, HYVs and Fertiliser on Yield of Rice**

The importance of irrigation in increasing agricultural productivity has been widely recognized across the world. Dhawan (1998) rightly pointed out that irrigated agriculture is the main source of growth of the crop sector, more specifically foodgrain production. Accordingly, the increase in food production is expected to come mostly from irrigated agriculture. According to Vaidyanathan (1994) more extensive and better irrigation facilities, varietal improvement and increasing use of' fertilizers have been the main sources of sustained growth of agricultural production in India. However, there is a remarkable disparity in the performance of irrigated and rain-fed agriculture. The study of Vaidyanathan and Rajagopal (1992) revealed that the output per hectare of irrigated area showed a significant rising trend as compared to un-irrigated land.

Goswami and Chatterjee (2003) studied the factors responsible for the slow growth and instability of area, production and productivity of rice in Assam with the help of secondary data. According to their study, the production and productivity of rice were higher during the green and post-green revolution period as compared to pre- green revolution period. This is because during the green revolution period, many farmers adopted the modern farm technology in rice cultivation. Although, the adoption of modern farm inputs increased the production and productivity of rice in the state, the problem of unequal distribution of such technologies hinders the overall development of rice in the state. According to them, un-equal distribution of high yielding variety of seeds, low fertilizer consumption, frequent heavy flood, and climatic condition are the main factors responsible for the variations of paddy yield rate in Assam.

Goswami and Chatterjee (2006) examined the impact of modern farm inputs on the yield of both kharif and rabi paddy in Assam. The modern farm inputs such as irrigation, fertilizer, high yielding variety, etc. were included in the study. To examine the impact of the irrigation, fertilizer and high yielding variety on paddy, the log linear (Cobb-Douglas) production function was used. According to their study, uses of fertilizer showed a positive and significant impact on kharif paddy in Assam. On the other hand, impact of flood was negative but significant. The impact of rainfall showed positive, but insignificant on the yield of kharif paddy. On the other hand, the irrigation, fertilizer consumption, HYVseeds and rainfall explained about 87 percent of Rabi paddy yield variation in Assam. Hence, it is concluded that, uses of fertilizer and flood are the major factors which influence the overall paddy yield in Assam.

Desai (1984) analysed the area, production and productivity and investigated the reasons behind the low productivity of rice in eastern India. In his analysis five states such as Assam, Orissa, Bihar, West Bengal and other north-eastern states were included in the study. To study the variation of area, production and productivity, coefficient of variation was calculated for both district level and state levels. The study found that, the production and productivity of rice in all the selected states were very low except in West Bengal. These states together contributed only 45 percent in the country. The study further revealed that, these states are lagging behind in the uses of HYV seeds. Owing to poor irrigation facilities and other natural calamities such as floods and droughts, the uses of HYV seeds in these states were very low. The poor growth rate of adoption of HYV seeds indicates that the proper rice technology or technologies had not evolved in various parts of the eastern states.

Upadhyay (2012) analysed the impact of climate variability on the rice productivity of Assam. He further tried to find out the impact of climate change on rice productivity in Assam. The study was based on secondary data for the period 30 years. The study estimated the Cobb-Douglas production function in the form of log-linear model and multiple regressions. The estimated results indicate that rice crop has a negative impact on its productivity due to increasing temperature and rainfall has a positive impact on the productivity of this crop in Assam. Bosumatari and Goyari (2010) analyses the factors behind the low productivity of rice in Assam during 1980-81 to 2003-04. The study found that the yield level in Assam was very low and well below the national average. According to their study, poor infrastructure facilities (such as marketing, transportation, etc.), use of low level of modern farm inputs (fertiliser, area under HYV seeds, systematic irrigation, credit, etc.) and climatic factors (heavy rainfall and floods) etc. are the major factors behind low productivity of rice in the state during the study period.

Sharma (1992) made an attempt to analyse the irrigation development and its impact on foodgrain production and productivity in Assam. According to his study, with proper agricultural practices and irrigation management, it is feasible to step up cropping intensity and productivity levels in a significant manner. Thus, the study found the positive correlation between extensions of irrigation facilities, especially perennial irrigation and crop intensity & productivity.

The study of Bezbaruah (1994) observed that in spite of widespread adoption of high yielding varieties the overall agricultural productivity has not improved in the state. The main reason behind the low productivity is due to the fact that farmers were not able to adopt and use them extensively and effectively. According to him, limited availability of developed irrigation facilities, inadequate rural credit system, loopholes in extension services, etc. were the major problem faced by farmers in the utilisation of HYV seeds in the state. Moreover, the study found that full utilisation of the potentialities of the new technology requires adequate application of the complementary inputs of fertilisers and irrigation with the HYV seeds.

Goyari (2014) examined the impact of seasonality of irrigation on the adoption and yield of paddy in Udalguri district of Assam. In his study, both varieties (traditional and HYVs) were also taken into account to examine the impact of irrigation on both varieties of paddy. According to him, yield of paddy was observed to vary with irrigation conditions. The yields of both varieties were observed to be the highest under irrigation condition of Borewells and Pumpsets. However, the yield of HYV paddy was significantly higher than the yield of traditional variety paddy in all three irrigation conditions. The productivity of paddy in rain-fed was the lowest among three irrigation conditions. Moreover, the study also found that adoption of HYV paddy seeds along with the application of chemical fertiliser and use of systematic irrigation water increased the yield of HYV paddy.

Dutta (2011) in his work on irrigation potential in agriculture of Assam analysed the impact of irrigation on yield of rice. According to his study, there is a variation in yield of the rice in different irrigation schemes. The yield per hectare has been recorded to have varied from 1612 kg per hectare to 4447 kg per hectare. Systematic use of irrigation along with fertiliser and HYV seeds gave higher productivity of rice in the state. According to him, the systematic use of irrigation and availability of irrigation encourages the farmers to adopt modern farm inputs and increase the cropping intensity and productivity.

Shukla et al. (2003) examined the factors responsibility of inter-state variability of rice productivity in India. The study found that, unequal distribution of fertilizer, credit supply along with erratic weather conditions and socio-economic factors are the main factors responsible for the inter-state variations of rice yield in the country. In addition to yield variation, these factors together are also responsible for low rice productivity. Factors such as lack of mechanization, lack of technical knowledge, low purchasing power, low efficiency of farm labours and conservative thinking also help in bringing down the rice productivity in the country.

Bastiaanssen and Zwart (2004) measured the crop water productivity of rice, wheat, maize and cotton. The study found that the productivity of crops which are grown in irrigated area return higher as compared to un-irrigated land. The values of water productivity were higher in proper irrigated land area than the less irrigated land area. Thus, the study concluded that irrigation is the most important factor for increasing production by increasing productivity. Hence, using irrigation in appropriate and timely will increase the value of water productivity of any crop.

Nirmala (1992) examined the constraints in rice production in Madurai district of Tamil Nadu. The study found that due to unequal uses of fertilizer both in rabi and kharif seasons, the productivity of rice in these seasons was unequal. In addition, the author also found that low level of fertilizer consumption, lack of pesticides used, lower capital flows and low net return were the major determinants of the low yield rate of rice in Tamil Nadu. Moreover, the biophysical factors such as water shortage, insects and socio-economic bottlenecks also contributed in reducing the yield level of rice in the study region. Similarly, Tuong 2008) made an attempt to study the productivity of rain-fed paddy as compared to irrigated paddy in Thailand. The study found that the productivity of rice in irrigated area was higher than rain-fed area. This indicates the necessity of irrigation in increasing productivity of rice crop. Thus, creating enough irrigation is very important to increase the productivity.

Kainth and Mehra (1985) studied the various constraints and factors responsible for variation of rice production and productivity in Amritsar district of Punjab. The study found that due to drought, attack of diseases, and attack by insect and pest the productivity of rice declined and it decreased the overall rice production in the district. The estimated multiple regression result showed that, demographic and fertilizer consumption were the two factors which affected the rice productivity positively and significantly. In addition to these factors, other factors such as climatic condition, technological and institutional factors were also responsible for low rice productivity in study district. Bouman and

Tuong (2001) also found that proper management of field water to save water is important in increasing productivity in irrigated lowland rice. According to them, saving water for the dry season to increase the productivity is necessary. The study also found the positive and significant correlation between irrigation and rice productivity. Thus, there should be an appropriate investment in irrigation.

Haque (1985) examined the factors behind the inter-district and inter-farm variation of rice yield in West Bengal during 1970-1984. Further, he also tried to find out the factors behind low yield of rice in the state. The estimated coefficient of variation results showed that the rice productivity was higher in irrigated area with low rainfall and high consumption of fertilizer. On the other hand, the rice productivity was low in a low area under irrigation, low level of fertilizer consumption and relatively high level of the average rainfall region. The estimated regression results also showed that the use of irrigation, proportion of area under HYV and higher amount of fertilizer consumption were the important determinants of rice yield in West Bengal during the study period.

Mythili (2008) examined the yield and acreage responses for major crops using the Nerlovian adjustment cum adaptive expectation model. He further tried to examine the yield response during the post and pre-reform periods with the help of available secondary data. The study revealed that yield response is higher than acreage response and significantly higher in the post reform period. Major non-food crops like rapeseed and mustard had the highest yield response than food grains like cereals, rice and wheat. In addition, the higher yield response during the post-reform was due to the introduction of new technology in agriculture sector. According to him, lack of available irrigation, production risk due to adverse weather and institutional constraints like presence of intermediaries were the major factors of poor yield response. Accordingly, he suggested for forming the strong policy for farmers to formulate adoption of an appropriate cropping pattern for optimum use of water.

Raju (2005) studied and identified the factors responsible for regional variation in Indian foodgrain production during 1995-2003. The linear regression model was fitted to estimate the significance and influence of variables in foodgrain production. According to his study, the regional disparities in foodgrain production increased considerably during the green revolution period. The main causes of increasing disparities of foodgrain production during the green revolution period were due to the introduction of new farming technology (such as systematic irrigation, fertiliser utilisation, use of HYV seeds etc.) in some parts of the country. Due to new technology, some states could produce higher as compared to other states where the new technology was not much famous. Thus, the unequal distribution of modern farm inputs and agricultural infrastructure, endowment and difference in agro-climatic conditions within the state were the major factors that influence the regional variations in foodgrain production during the study period.

Attri and Rathore (2003) studied the impact of climate change on wheat production using the resources and environment synthesis-wheat simulation model. The study found that the climate change has direct and significant connections with crop growth, water use and productivity. The effect of increasing Carbon dioxide concentration will have the impact on crop productivity for formulating strategies. For the crop growth model, the probable changes in the surface air temperature during the growing season were estimated using the standard rationalization techniques. They found that the productivity increased about 29 percent in rainfed wheat and 37 percent under irrigated conditions in different genotypes under modified climate. The impact of modified climate was observed to be higher under rainfed condition than under irrigated ones for all genotypes. The mean yield was found significantly affected by different climatic conditions.

Bhattacharyya and Bhattacharyya (2007) made an attempt to study the trends and growth of foodgrain production in West Bengal. The author divided entire study period into pre-liberalization and post-liberalization. To estimate the extent of instability, the log quadratic model was used. The study found that the foodgrain production increased considerably during 1980s but decreased from 1990s in West Bengal. Although there was a tendency of increase in yield rate due to late impact of green revolution in the state, owing to decreasing fertilizer consumption, declining area under HYV seeds, decline in cropping intensity and declining institutional credit supply dwindled the productivity of foodgrain in West Bengal. Thus, above mentioned factors are the main factors responsible for the poor foodgrain production and productivity in West Bengal during post-liberalization period.

Rajeevan (2013) analysed the impact of climate change on production and productivity of crops. Agriculture sector in general and crops production in particular is considered to be sensitive which is influenced by the projected global warming and associated climate change. Carbon dioxide effect, changes in temperature, water run-off, climatic variability by droughts, floods etc. affect directly the agricultural crops. According to his study, although the direct impact of climate changes is small on kharif crops yet kharif crops become vulnerable due to increased incidence of extreme weather such as in rainy days, rainfall intensity, duration and frequency of floods, asymmetry of temperature, change in humidity and virulence, etc. On the other hand, production of rabi crops is comparatively more vulnerable due to larger increase in temperature, asymmetry of day and night temperature and higher uncertainties in rainfall. It revealed significant variations in monsoon rainfall and surface temperature influence the foodgrain production and productivity in the country. Vasanta (2013) also analysed the impact of climate change on the production and productivity of wheat and rice crop in Himalayan region. The climate change was found to be having positive and significant effect on yield fluctuation of many crops. Increasing glacier melting in Himalayas has also direct effect on the availability of irrigation which in turn has large consequences on food production. Small changes in temperature and rainfall could have significant effect on quality of cereals, fruits and aromatic with resultant implications on their prices and trade. In addition, the extreme weather temperature events like droughts, floods, tropical cyclone, hot heat waves and changes in monsoon have direct negative impact on agricultural production. The estimation results showed that the impact of climate change on wheat production varied significantly across regions.

Kumar and Sharma (2014) studied the impact of climate and non-climatic factors on the sugarcane productivity in different weather seasons. The estimated results showed that the climatic factors have negative influence on sugarcane productivity. Prais Winsten models on regression estimation showed that average maximum temperature and average minimum temperature in summer and rainy season emerged statistically significant and negative impact on sugar cane productivity. Further, rising average minimum temperature in winter and summer seasons signifies positive and statistically significant influence on the productivity of sugarcane. This implies that sugarcane productivity on different weather season has statistically significant on climate change, changing rainfall pattern and increasing average maximum temperature and minimum temperature in India. It also signifies non linear relationship between climatic change and sugarcane productivity. Estimated results further showed that irrigation, farm harvest price have positive and statistically significant influences on the productivity.

Thomas (2007) pointed out that irrigation facilities allow to explore the potential of the maximum yield while the rainfed crop yields are limited by natural wetness. The capacity to supply irrigation water is the key to further an expansion of agricultural production. Furthermore crop production in water scarcity has been attributed to declining precipitation rates, over use of groundwater as well as deteriorating irrigation structures and inappropriate water management. The result indicates that the condition and consequent of irrigation demand was subject to considerable variation both due to inter-annual and intra-annual climatic variability. He suggested that more efficient irrigation can save by water saving practices without decreasing yields.

Thus, the most of the existing studies showed that available irrigation facility along with other important factors like new farm technology adoption, input availability, land quality, price policies, marketing conditions etc. can play a great positive role in raising the productivity of rice and other crops in any region.

### 1.3 Motivations of the Study

The main motivation to carry out the present work is due to lack of available studies on the present topic mainly for Assam in general and for Chirang district in particular.

The state of Assam which lies in the high rainfall zone of the country is blessed with abundant rainfall and water resources. Generally, Assam receives, on an average, about 2909.60 mm normal rainfall every year. Although, the state usually receives good rainfall almost every year, it is not evenly distributed over time and space. This rainfall, however, is concentrated over a few months of the year, i.e., during June-September. The remaining eight months are generally dry or of low rainfall. Even during monsoon, the rainfall is scanty and unpredictable in many parts of the state. Sometimes, the monsoon is delayed considerably, while sometimes it ceases prematurely. Consequently, successful cultivation is not possible in large parts of the state without irrigation. This erratic nature of rainfall during monsoon creates twin problems of floods and drought in the state which make kharif crops vulnerable (Sharma 1992). Thus, this vulnerability of the kharif crops makes it all the more important that the area under and output of rabi crops should be expanded rapidly to compensate for the crop losses during the kharif season. On the other hand, the Rabi season which is associated with the dry months of the year is highly dependent on adequate and assured irrigation water. Hence, irrigation is crucial to agriculture as a primary source of water in the dry months of the year and to supplement rainfall in the monsoon season in the years of low rainfall.

Other than rainfall, Assam is richly endowed with naturally flowing water system. There are two principal river systems in the state which are the main sources of surface water flow - the Brahmaputra and the Barak River. The river Brahmaputra with a total length of 2900 km and a catchment area of 0.94 million square kilometres enters into the north eastern India and flows westwards through Assam (Sharma, 1992). Many big and small tributaries meet the river at different places of its course. The tributaries of the Brahmaputra can be classified into the northern bank tributaries and the southern bank tributaries. The northern bank tributaries are mostly perennial in nature. The Brahmaputra river system has immense potential for development of surface water irrigation in the state (Irshad, 1975). On the other hand, the numerous tributaries of Barak River also supply water in the state. The irrigation potential of the surface water resources is abundant to cover the whole Barak Valley. Although there is abundance of surface water resources in the state, because of limitations imposed by the topographical characteristics of this region, there is the reduced flow condition of the river water in winter months. Thus, it is necessary to explore the possibility of utilisation of ground water resources for irrigation in some areas within the state which cannot be provided with irrigation from surface water. Besides, the state has rich underground water resources due to the occurrence of heavy rainfall and advantages in soil formation. The north bank districts like Kamrup, Darrang and Sonitpur overlie the northern most piedmont belt. This belt is analogous to the Bhabar belt of Ganga valley and occurring close to the foothills is flawed to the south by a narrow terrain belt (Phukan, 1986). The piedmont terraces are highly permeable in nature and ground water prevails at a depth of about 30 metres below the ground level (Dutta, 2006).

In spite of such irrigation potential in the state, the state of Assam has been experiencing shortage of water for the agricultural purposes especially during summer and autumn season. The irrigation potential created through different schemes or different agencies shows clearly that, irrigation potential created in the state is far below as compared to other major agricultural states of the country. According to data provided by ministry of water resources, government of India, the potential irrigation created in Assam was 4.15 lakh hectares in 1996-2013. In the same year, the irrigation potential created in

Andhra Pradesh, West Bengal and Punjab was much higher than Assam. The potential created in these states were 4.72 lakh ha in Andhra Pradesh, 4.22 lakh ha in Punjab and 5.14 lakh ha in West Bengal. Moreover, the potential utilisation of created irrigation in the state was also found to be very low as compared to other major agricultural states of the country. Bezbaruah (1994) rightly pointed out that the problem of underutilisation was partly due to inadequate plan and lack of coordination among various agencies responsible for implementation of irrigation programmes of the state. Moreover, the study of Gohain and Gogoi (1986) found various firm level constraints for underutilisation of irrigation in the state. Some of these are prevalence of monocropping system among large farmers, lack of training, resources constraints among small and marginal farmers, non-availability of infrastructural facilities like quality seed and fertiliser in time, institutional credit, etc. Gogoi (1989) further observed that frequent breakdowns of the wells, irregular supply of electricity in case of deep tubewells, lack of proper knowledge of raising different crops are some of the major factors hindering the full utilisation of irrigation in the state. Besides, Saikia and Borah (1993) pointed out that the poor canal system leading to non-availability of irrigation at the time of requirement, loss of water in the process of conveyance and distribution, inadequate agricultural supports, etc. are the major factors responsible for underutilisation of irrigation. This is hampering the growth of agriculture sector of the state. There are also many studies in the literature who have found positive impact of irrigation on crop yield, fertiliser consumption, HYV seeds, cropping intensity, etc.

These studies are generally carried out only in a specific project, district and location only. Thus, one cannot generalise the factors that affect the irrigation sector in particular area with another areas. Thus, in present study an attempt has been made to examine the growth trends of irrigation and its impact on crop productivity with special reference to Chirang district of Assam.

As stated earlier, the main motivation to carry out the present study comes mainly due to the fact that only very few studies have been done so far on the present topic particularly in Chirang district of Assam. There are some studies on irrigation development and its importance in state level and some districts within the state. Some of these studies are Dutta (2011), Goyari (2008), Sharma (1992), Gohain and Gogoi (1986), Phukan (1985). In addition, there are also some studies which highlight the factors that affect the area production and productivity of paddy crops in the state. Some of these studies include Goyari and Sharma (2008), Talukdar and Beka (2005), Gogoi and Bharati (1993), Gogoi and Bharati (1993), Goswami and Chatterjee (2003, 2006), Goswami (1989). These studies were concentrated in different locations within the state. But for Chirang as a newly formed district, no such studies have been done so far on this particular topic. Therefore, the present study proceeds to study the development of irrigation and factors affecting irrigation development in the district with the help of primary field survey data. Moreover, the study also tries to examine the factors behind underutilisation of created irrigation in the district and consequent variations of seasonal paddy crop yields.

Another important motivation is due to the special characteristics of Assam as an agricultural state. Assam, which is located in the north eastern part of the country, has various natural resources like fertile land, forest and available water resources. Apart from rainfall, the state of Assam also has abundant natural flow water system. Through this naturally flow waterway system; the state has immense potential for the development of surface water irrigation. Besides, there are also rich underground water resources. In spite of such irrigation potential, the state of Assam has been experiencing of shortage of water for the agricultural purposes especially during summer and autumn seasons. Moreover, the utilisation of created irrigation in the state of Assam is also low. Various earlier studies have constantly pointed out that the financial constraint; technical problems, management problem, institutional factors, etc. are the main problems of poor irrigation development in the state. Based on various studies, effort has been subsequently made to improve by creating additional irrigation facilities. However, in spite of various policy implementations and steps undertaken, the irrigation sector has not been up to the mark. Thus, it is felt necessary to carry out such study on the irrigation sector for better understanding of various problems associated with the irrigation sector in general and on the present topic in particular.

Another important motivation is due to the special characteristics of Chirang district as an agricultural district. Like many districts of Assam, Chirang is also an agriculturally dominant district where majority of people depend on agriculture, mainly on paddy cultivation. Moreover, like many districts in Assam, Chirang district also has many sources of water for irrigation for cultivation. Unfortunately, available sources of water have not been utilized for fruitful irrigation purposes and even available irrigation facilities are sometimes not accessible to many farmers due to several reasons. Consequently, paddy production and productivity of Chirang remain to be very low and lower as compared to the state level or all India level. Therefore, an in-depth study is strongly felt on the present topic for Chirang district for better understanding of various problems associated with the irrigation sector in general and on the present topic in particular. Such a study is of significance not only for academicians but also for the planners, government and all those who are interested in doing something for the welfare about millions of farmers in Assam.

### 1.4 Objectives of the Study

In the light of above background and motivations, in the present thesis, an attempt has been made to examine the following main objectives.

(i) To examine the structure and development of irrigation in Assam,

(ii) To examine the utilization patterns of available irrigation facilities for paddy cultivation in the sample areas with the help of field survey data and

(iii) To examine the impact of available irrigation on seasonal paddy yield variations in the sample regions.

### 1.5 Hypothesis

The present study is based on the following hypotheses. Farming with proper irrigation system produces more and higher productivity as compared to rainfed farming. According to the studies of Dhawan (1998), Rao et al. (1992), Rosegrant and Perez (1997), Ringler et al. (2000), Hussain and Hanjra (2004), Lipton et al. (2005), Munir et al. (2002), crop yields everywhere in the developing countries of the world are consistently higher in irrigated areas than in rainfed areas. According to them, the direct benefits of irrigation include higher farm productivity through crop yield increases and diversification of cropping patterns and crop technologies.

### 1.6 Data Sources and Methodology

The present study uses both secondary and primary data. The secondary data were collected to study the growth and development of irrigation system in Assam. Related data on irrigation of other states are also collected to compare the performance of irrigation in Assam with other states of the country. Time series data on irrigation, gross area irrigated, net area irrigated and area under irrigated rice and difference sources of irrigation were collected from various sources like Statistical Hand book of Assam; Economic Survey of Assam; CMIE and Directorate of Economics and Statistics (Govt. of Assam); Office of the Chief Engineer, Irrigation Dept, Govt. of Assam; Directorate of Economics and Statistics (Govt. of India); Agriculture Statistical at Glance, Govt. of Assam; Economic Survey of India; Agriculture Statistical at Glance, Govt. of India; Directorate of Rice Development, Patna; Agriculture Census Report, Minor Irrigation Census, Indian Meteorological Department, Govt. of India; North Eastern Regional (NER) Data Bank; Fertilizer Statistics, Govt. of India and Tea Board of India.

In addition, the primary data were collected to get into more intensive information at the micro level, i.e., household level. The main motive behind collecting primary data was to collect more detailed information into the land utilization pattern, cropping pattern and irrigation utilization patterns. Moreover, data related to availability of irrigation and utilization of irrigation among sample households were also collected through primary field survey. Primary data were collected from ten villages in Chirang district of Assam. The selection of sample household and villages were made through multi-stage sampling method. At the first stage, Chirang district was selected. The District has two sub-divisions, namely, Kajalgaon and Bijni. These two sub-divisions are further divided into six revenue circles and seven development blocks. At the second stage, a list of major sub-divisions was made and from these sub-divisions, Bijni sub-division was selected. It has six revenue circles, namely Bengtol, Bijni, Bongaigaon (partly), Barnagar, Kokrajhar (partly) and Sidli. Then, Bijni revenue circle was selected at the third stage. At the fourth stage, we have listed all the development blocks under Bijni revenue circle and selected Borobazar development block for the field survey. At the fifth stage, from Borobazar development block, a total of ten villages have been selected. The selection of the sample villages was done on the basis of availability of irrigation facilities. Five villages were selected in irrigated area and five villages were from less irrigated area. These villages are Hasaobari, Simlaguri, Gopdapara, Gengraypara, and Dologaon, Bautipara, Landanguri, Puradia, Baoraguri and Batabary. In the last stage, the selection of sample households was done randomly. Accordingly, total 320 sample households from these ten sample villages were selected, i.e., 134 households from region 1 or irrigated region and 186 sample households from region 2 or less irrigated region respectively. The primary data were collected at the household level using the structured questionnaire/survey form.

For the analysis of data, both qualitative and quantitative methods have been adopted. Collected data were tabulated for the analysis purpose. The regression analysis is adopted to examine the influence of irrigation on productivity of seasonal paddy. The rice yield response function was estimated to acquire information of the direction and extent of relationship of rice yield and irrigation.

### 1.7 Organization of the Thesis

The thesis is organized into seven chapters. The first chapter is the introduction chapter. This chapter deals with the introduction of the problem, motivation behind the present study, objectives, data sources and methodology. A brief review of literature on the irrigation development issues has also been given in this chapter. In chapter 2, an assessment of growth and trend of irrigation in Assam as compared to other states of the country is done with the help of available secondary data. Further, we have discussed briefly different sources of irrigation in the state. Chapter 3 is the description of field surveys and primary data collection. In this chapter, we have discussed the method of data collection, and selection of sample households. Chapter 4 describes the general profile of sample households where main items are on the demographic characteristics, occupational structure, and land use pattern, cropping pattern and irrigation sources. Chapters 5 and 6 form the main chapters of the thesis. The analysis of availability and utilization of irrigation among the sample households is made in chapter 5. Some of the important items examined in this chapter are availability and seasonal variations of irrigation in the sample, and the factors affecting the irrigation development in sample villages. Chapter 6 is on the discussion of how the irrigation is affecting the yield of paddy crops across seasons and across sample households. The yield response function was also estimated econometrically to examine the influence of irrigation, fertilizer and HYV area to the paddy yield for three seasons. Finally, chapter 7 provides the broad summary of the study and derives some policy implications.

## Chapter 3
## Field Surveys and Descriptions

### 3.1 Introduction

The previous chapter discussed the overview of irrigation scenario in Assam based on the secondary data at the state and district levels. The study on macro level sometimes fails to capture the problems that are actually prevailing on the ground or micro levels. They fail to provide answers to many significant questions. Thus, to obtain the ground level scenario on the problems of irrigation sector in the state, it is necessary to carry out detailed investigation at the micro level. Therefore, a field survey was conducted in selected villages of Chirang district of Assam to gather information of irrigation. Accordingly, the field survey was conducted in 2012. The methods of data collection, description of field survey data, selection of sample villages and sample households are briefly discussed in this chapter. Accordingly, the present chapter is organized into three main sections. Section 3.2 deals selection of the study district and its profile. Section 3.3 deals with selection of sample villages and sample households. In section 3.4, a brief description of primary data collection is discussed.

### 3. 2 Selection of Study Area: Chirang District[1]

At present, Assam has 29 districts. Out of these districts, present study is confined to Chirang district which is a newly formed district of Assam. The selection of Chirang district is anticipated to make a thorough study of availability of irrigation in the district as compared to other districts of the state. Being a newly formed district in the state, no proper studies on the present topic was found in the literature. Therefore, it is felt necessary to carry out detailed investigation on the present topic at the district level.

The district was curved out of the existing districts of Kokrajhar, Bongaigaon and Barpeta. Chirang is one of the four districts of Bodoland Territorial Area District (BTAD)

[1] Data were mainly collected from websites of www.assam.gov.in, www.chirang.gov.in (accessed in January, 2014), and Chirang District Administrative Office, 2013.

created within Assam under clauses 6 of article 332 by the $90^{th}$ Amendment Act 2003 of Constitution of India. The district is situated at the Northern bank of Brahmaputra River under lower Brahmaputra valley zone of Assam. "Chirang district of Assam lies between 26.28 N and 26.54 N longitudes and 89.42 E and 90.06 latitudes at an altitude of about 52 meter above the mean sea level. The district is situated in North-Westside of Assam surrounded by Bhutan in the north, Bongaigaon district and a little portion of Kokrajhar in the south, Kokrajhar in the West and Baksa district in the east. Major tributaries of the river like Champamati, Aie and Manas are flowing through the hearth of district from north originating in Bhutan to the south and join the mighty river Brahmaputra". Besides, many tributaries small rivulets and streams are flowing in the district and this mainly contributes towards the provisions of the agrarian economy of the district. The district possesses a plain topography. It has also undulating areas. "There are four types of soil found in the district such as Entisols (steep and rocky setting), Inceptisols (humid and sub humid), Alfisols (Semiarid to humid areas) and Ultisols (red clay soils)".

Agro-climatically, the district falls under the North Bank Plain zone and also conducive for various agricultural activities. Therefore, the district has a sub-tropical in nature with warm and humid summer followed by dry and cool winter. The highest temperature is experienced during the period of south west monsoon along with abundant rains. "The mean maximum temperature of the district varies from $33^0$C to $38^0$C and minimum temperature $9^0$C to $10^0$C. The average annual rainfall is about 1951 mm per annum of which 75 percent is received during monsoon months (June-September). The monsoon months are wet and winter months are relatively dry. Both pre and post monsoon months have unpredicted and erratic rainfall. During June-September, heavy rainfall occurs due to south west monsoon for which the district experiences heavy flood".

There are two major towns in Chirang district namely Bijni and Basugaon. Besides two towns, there are total 410 villages in the district. District has two sub-divisions namely Kajalgaon and Bijni. Kajalgaon is the head quarter of the Chirang district. These two sub-divisions are further divided into six revenue circles. These revenue circles are Bengtol, Bijni, Bongaigaon (partly), Barnagar, Kokrajhar (partly) and Sidli. The district has seven development blocks namely Borobazzar, Chakchaka (partly), Gobardhana (partly), Dangtal, Kokrajhar (partly), Manikpur and Sidli. However, the main development blocks under Chirang district are Borobazzar Development block and Sidli-Chirang development block respectively.

According to the census, 2011, the total geographical area of the district is 1975.42 sq km. with a total population of 481818 persons. The population density of the district is 384 person per.sq km. Of the total population of the district, 3, 86,050 persons live or settle in rural area which is nearly 80 percent and 25008 persons live in urban areas. Out of total population 2,44,673 persons are males and 2,37,143 persons are female population. The Schedule Castes and Schedule Tribes Population together account for about 52.34 percent in the district. The majority of Schedule Tribe populations in the sample district are Bodo Kachari group which constitutes around 80 percent.

As per the literacy is concerned, the literacy rate of the district is only 64.71 percent (census 2011). The district has total 47 secondary and higher secondary schools, 112 upper primary and 922 lower primary schools. Besides government schools, many private (English medium, Bodo medium and Assamese medium, etc.) schools and central schools also exist in the sample district.

According to census report, 2011, out of the total population of the district, about 1, 93,894 persons are workers. Within the workers, about 80,328 persons are cultivators, 35,224 persons are agricultural labourers and 54,867 persons are marginal farmers. Among male workers, 72.18 percent are cultivators and 27 percent are marginal workers. Hence, about 48.38 percent of the working populations are engaged in agriculture farming (i.e. cultivators and agriculture labourers) in the district.

The distribution of geographical area shows that, out of the total geographical area in the district, 60239 hectares are agriculture lands and 7042 hectares are for non-agricultural uses. Forest area covers about 9648.71 hectares of the total geographical area. However, permanent Pastures land covers about 6842 hectares and 5730 hectares of lands area is under trees crops, groves and other fallow land etc. Moreover, out of the total geographical area and other pastures lands, about 7042 hectares of land are not available for cultivation.

Agriculture is the mainstay of the people in the district. Agriculture in the sample district is characterized by over dependence on rainfall, predominance of seasonal crops and traditional methods[2] of cultivation like any other districts of the state. Heavy rainfall coupled with high intensity of wind causes severe soil erosion, particularly on upper reach and in flood prone areas. Mass ravine erosion and river bank erosion are the main types of erosion commonly seen during agricultural year in the district.

Rice is the main crop grown in the district and mono-cropping of rice is a common practice in most of the rice growing areas. Rice occupies about 57 percent and 43 percent of cropped area during Kharif and Rabi seasons respectively. Like other districts, Chirang also cultivates varieties of food crops and non-food crops. Other than rice, crops like wheat, rape & mustard, oil seeds, jute, black gram, green gram, sugar cane, etc. are also grown in the district. Moreover, Rabi & kharif vegetables, ginger, turmeric, coconut, areca nut, pineapple, banana, citrus etc. are also widely grown in the district. Among all the food crops, paddy, wheat and maize are the most important crops in the sample region. Sugarcane is the commercial crop widely grown in the sample region.

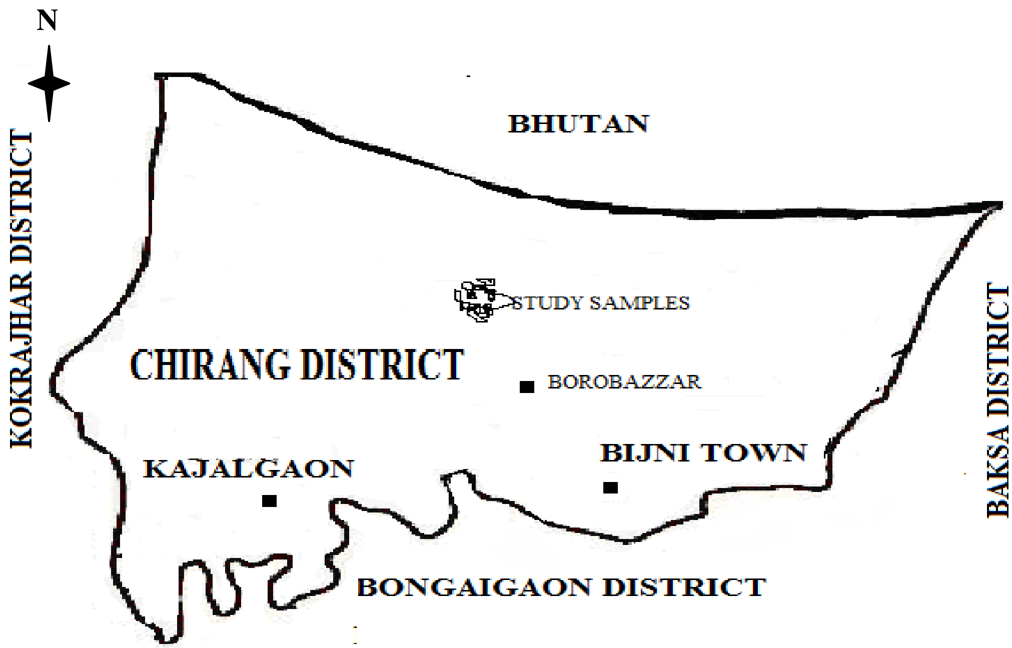
The district is blessed with endowed natural and mineral resources and has high potential for industrial growth. The existing industrial base of the district encompasses the BRPL (Bongaigaon Refinery and Petro-Chemicals Limited) is one of the large scale industries of the entire region. The BRPL industry directly generates evenly employment to both skilled and unskilled labours. Apart from large scale industries, there are also small scale industries like spinning mills at Noapara, Commercial estates under Bijni sub-division and Carbon factories in Sidli sub-division along with many tiny and cottage industries.

The infrastructure in the district such as transport and communication system has semi better connectivity with road ways and railways. The national highway No.31C passes through the heartland of the three districts, i.e, Kokrajhar, Chirang and Baksa. The railway line (Broad Gauge) is also well connected by Indian railways that run west to east direction passes

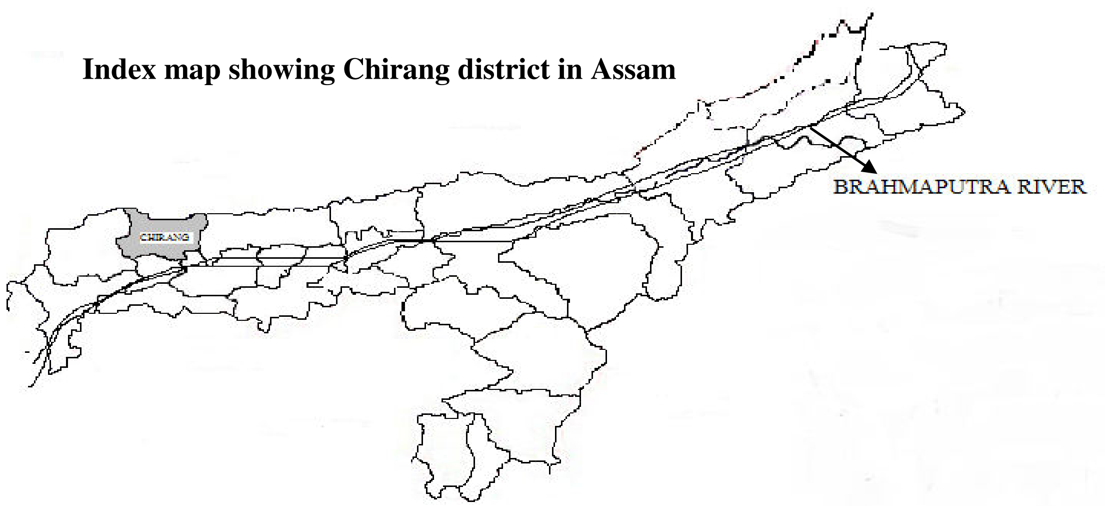
[2] Traditional method of cultivation indicates a means of producing crop where the farmer has a mixture of farm crops and livestock. The farmer uses manure from the livestock to fertilize the crops. It is also a technique or method where paddy saplings are re-transplanted twice (called Kashiya Gainai in local) for early flowering of paddy because it avoid risk or probability of the outcome even there is less accessibility of water.

through the hearth of the district towns of Basugaon and Bijni along with sub-station Chaprakata, Dangtol, Kudumtola and Bangaldoba. Besides the New Bongaigaon junction is about 12 km away from the district head quarter. The distance from the district head quarter to Guahati city is 200 km connected by National highway No.31, NH31 (B) and 31(C) which passes via Baksa, Barpeta, Nalbari and Kamrup. The nearest town from head quarter is Bongaigaon which is 13 km followed by Basugaon, Kokrajhar and Bijni. Furthermore, there is a pucca road which connects the district with Gelegphu in Bhutan, the bordering town with the neighboring country. Moreover, there are three city bus stands -one in Sidli sub-division, one in Bijni sub-division and one in Manikpur revenue block. Although, the district is connected with national highways and railways, the road connection are not up to the mark within the district.

Figure 3.1: Sketch map showing study area locations in Chirang of Assam




**Index map showing Chirang district in Assam**



### 3.3. Selection of Sample Villages and Households

To select the sample areas for the present study, first we have made a list of all districts in the state. Only one district (Chirang) is selected for the present study. Secondly, we have listed all the sub-divisions of the district. There are only two sub-divisions, namely, Bijni and Kajalgaon in the district. Out of these, Bijni sub-division was selected for the field survey. In the third stage, the selection of development blocks was done. Under the Bijni sub-division, there are two development blocks -Borobazzar and Manikpur. Of these two development blocks, we have selected only Borobazzar development block. The selection of Borobazzar Block was made by keeping in mind of the availability of water for irrigation. There are two main rivers flowing through the hearth of Borobazzar block of Bijni sub-division. The tributaries of these two rivers give immense opportunities for the irrigation development in the sample block compared to other blocks. Thus, Borobazzar block is selected for the present study to analyze the potential of irrigation development and impact of irrigation on agriculture development in the block. In the fourth stage, we have listed all the 340 villages under the Borobazzar development block. After listing all the villages, we have selected ten villages for the field survey. The selection of the sample villages was done on the basis of availability of irrigation facilities. For this we have divided the villages into two regions - More Irrigated Region, and Less Irrigated Region. For our convenience, we termed the More Irrigated Region as Region 1 and Less Irrigated Region as Region 2 in our present study. Region 1 includes all the villages which are nearer to the tributaries of the rivers and received proper water for irrigation development. On the other hand, Region 2 includes all the villages which are far from the tributaries of Makhra and Aie rivers and received less water for irrigation.

Thus, we have selected total ten villages from these two regions, five villages from each region. Villages in Region 1 include Hasaobari, Simlaguri, Gopdapara, Gengraypara and Dologaon. On the other hand, Bautipara, Langdanguri, Puradia, Baoraguri and Batabary villages are included in Region 2.

In the fifth stage, the selection of sample households is done from the sample villages. To select sample households, we have listed all the households of all the sample villages. After listing all households, we have selected only those households who are engaged in agricultural activities. In other words, we have excluded those households who are not in agricultural work. Accordingly, we have selected total 320 sample households from these ten sample villages. Total 134 sample households were selected from More Irrigated Region 1 and 186 sample households were selected from Region 2. The list of these sample villages is presented in Table 3.1.

Table 3.1: Region-wise distribution of sample villages

| Region 1 | Sample HH | Region 2 | Sample HH | Total Sample HH |
|---|---|---|---|---|
| Hasaobari | 30 | Bautipara | 28 | 58 |
| Simlaguri | 31 | Langdanguri | 42 | 73 |
| Gopdapara | 12 | Puradia | 44 | 56 |
| Gengraypara | 22 | Baoraguri | 44 | 66 |
| Dologaon | 39 | Batabary | 28 | 67 |
| **Total** | **134** | **Total** | **186** | **320** |

Source: Filed Survey Data,2012

### 3.4 Description of Field Survey and Data Collection

The main analysis of the present study is based on primary data collected from sample households. To collect primary data from the sample households, a set of structured questionnaires/schedule was prepared. With the help of the questionnaire, the field survey was conducted in the sample villages. A major part of the data for the study was collected through personnel interview. In addition to personal interview, the informal discussions and personal observations were also done during the survey. Thus, intensive data were collected with the help of interview schedule, observation and informal discussions. The primary sources of data were derived from an interview scheduled which was administered to the respondents. The field survey programme for this study has been organized in two phases. The first phase survey was carried out during January- April 2012 and the second phase of survey was done during October- November 2012. The purpose of two phases of surveys was done to cover the different crop growing seasons. Generally, in Assam the crops are grown in three different seasons. Thus to cover the crop growing seasons, surveys was conducted in two phases. Apart from two field survey, a pilot study was also made to collect preliminary information of the households during November- December, 2011.

**(i) Pilot Study:** Before main field surveys were conducted, a pilot study was made. The main objective of the pilot study was to get prior information regarding the sample field. Thus, in order to have an overall idea of the villages and the concerned district, a pilot survey was made during the period of November-December, 2011. After tentative identification of the sample villages in the district through secondary information based on maps and pre-field visits, the first field survey was conducted.

**(ii) First Field Survey**

The first phase of field survey was conducted during January-April 2012. During the first survey almost all the information on household such as demographic information, land holding pattern, sources of income, plot-wise distribution of crops, season wise distribution of plot, agricultural implements, adoption of modern farm inputs such as fertilizer, irrigation, pesticides, etc. were collected. The questionnaires were prepared on different aspects related to irrigation keeping in view the objectives of the study. The data collected from field study were classified and tabulated properly to examine the stated objectives. The responses of the respondents have been analyzed and interpreted to find out the trend and pattern of irrigation development, seasonal variation of utilisation of irrigation and its impact of paddy productivity in the sample study.

**(iii) Second Field Survey**

In addition to first field survey, the second field survey was conducted during September-October 2012. The main purpose for second field survey was to collect data related to autumn crops. The questionnaires for both surveys were same. However, same sample households were interviewed in second field survey also.

Apart from structured questionnaires, some information was collected through the personal observations during the field surveys. The questionnaires were restricted type and the subject had to be answered from among several choices. To avoid certain limitations in the questionnaires, an alternative (any other) was provided in most of the questions for unanticipated responses (see Appendix-A.3.1 for the format of the questionnaire). The persons interviewed were generally the heads of families irrespective of sex. Brief descriptions have been given below on the headings of data covered in the household questionnaires.

**General and Demographic Information of the Sample:** The general information relating to location, geographical boundary, distances from headquarters or sub-division, name of the villages, transportation and communication system, postal address, etc. were collected from the sample households. The information of households such as caste, community, religion, etc. were collected from the head of the households. In addition, demographic information on household members like age, gender, educational status and marital status were also collected from the head of the households for the present study.

**Information of Income and Expenditure of the Households:** Information on different sources of income such as wages, salary, agricultural activities, livestock rearing, small business and other income sources of the households were also collected through questionnaires. Although, the information of their income from various sources was not accurate, yet many sample farmers have given some rough information regarding their income. Moreover, data on annual composition of expenditure on food and non-food items were also collected. The collection of information on annual expenditure was done to check the expenditure made by households on agricultural inputs such as expenditure on irrigation, fertilizer, HYV Seeds and other inputs. The annual expenditures on food stuff, children's education, health, social activities, etc. were also collected.

**Information of Land Holding:** Information on nature of land holdings among sample households were collected through questionnaire. Assam is blessed with varieties of land quality such as fertile, sandy, loamy, clay, rocky. Thus, collection of land quality information was felt important. Other than land quality, we also have collected information on approximate current quantity of land holding (in bigha) and lease status, irrigation status, terms of lease, etc. Information on lease status such as own land, leased in, lease out, mortgaged in, mortgaged out and Adi, etc. were also collected from sample household. In addition, if at all they leased their land, what are the terms of leased? The information on terms of leased was also collected. There are different types of terms of lease such as sharecropping, cash rent, kind rent, etc. Further, information on sources of irrigation such as rain water, natural flow waterways, canal, tubewell, dams, sprinkle, tank etc. were also collected from the sample households. In addition, information on land holding across seasons was also collected. For this purpose, name of the land and area (in bigha) were recorded. In this item we have recorded how much land is used for summer, winter and autumn seasons. Information on location of land with quantity of is also collected.

**Cropping Pattern and Distribution Land across the Seasons and Crops**:_Data were collected on the names of crops grown, area and total output. Most of the respondents have given approximate report since they do not keep any report on plot-wise and crop-wise. But there were some respondents who keep their record and could tell the correct amount of production of different crops. Most of them were easily able to tell the correct answer on crops like rice and other major vegetables. In addition, information on plot-wise and crops-wise were also collected from sample farmers. Uses of inputs are different across plot and across crops. Thus, we have collected information on each crop and each plots of land. Most of the land areas are under the paddy cultivation in the sample. Thus, using inputs such as irrigation, fertilizer and HYV seeds differ across crops. Information on uses of fertilizer across crops and across seasons was also collected from sample farmers. The uses of fertilizer differ from farmers to farmers. Some farmers use more fertilizer in one season than others. The uses of fertile depend on quality of land and availability of irrigation facilities.

**Information on Irrigation:** Data on irrigation was also collected from the sample farmers. Availability and accessibility of available irrigation in the sample through different sources of irrigation were collected. Data on land area under irrigation across seasons and across farmers were also collected. Information on cost of irrigation uses is also collected.

**Information on Agricultural Implements:** Data on agricultural implements were also collected from the sample farmers. There are different types of tools that are used in production process. Some of these tools are steel plough, wooden plough, power tiller, bore well, tractor used for agriculture, bullock cart, hand/power spray, drip irrigation implement, sprinkle irrigation, grain cleaner, threshers, diesel pumpset, etc.

**Information on Beneficiary of Irrigation Schemes:** Data were collected on the beneficiary of irrigation schemes provided by minor, major and medium irrigation projects. In this regard, we have collected information on whether the farmers are satisfied with the irrigation facilities provided by both government and private agencies. Further, information was collected on types of irrigation facilities available in their villages. If no irrigation facilities, is there any proposal for construction of irrigation facilities in the area by any agency? In addition, the information related to current status of any irrigation projects that are available in the village. Is the irrigation facilities that have been created are still functioning well and are those accessible to all the farmers over time and space? Such information was also collected.

**Opinion on Not Using Irrigation by Sample Farmers:** We also have prepared a question to acquire the information on why the farmers, if any, in the sample area are not using irrigation in the process of cultivation of various crops. In this regard, different farmers have given different reasons of being using irrigation. Some farmers have said that the cost of using irrigation is high, thus they are not able to afford it. Most of the farmers have said they are not using irrigation facilities in their plot, because of damage by erosion during rainy season. And some have said they are not aware of any of modern irrigation schemes.

**Information on Credit:** Data were collected on total loans taken/money borrowed by households from various sources. For each loan, data were also collected on the purpose, the principal amount, the rate of interest, nature of repayment, the amount repaid and remaining.

### 3.5 Summary

This chapter discussed the selection of study area and field survey data collections. Sample data were collected from ten sample villages in Bijni sub-division of Chirang district in Assam. The total sample included 320 farmer households. Primary data were collected by using the systematic survey form. For most families, the head of the sample household was the respondent of the survey. The chapter also described the brief profile of sample district.

In the next chapter, we proceed to discuss the general profile of sample villages and farmers in a more detailed way on the basis of primary field survey data.

**Appendix 3.1: Questionnaire for the Field Survey**

**Irrigation Development in Assam: A Study on Utilisation and Seasonal Variations**

(A Survey as a Part of PhD Thesis of Mr. Devonath Narzary)
Interview Schedule / Questionnaire for Household Farmers
Reference year 2012

Date of Interview: …………………………………………………………………….

Name of the Investigator: …………………………………………………………….

Name of the Respondent: …………………………………………………………….

Name of the Head of the household/ Farmer: ……………………………………

Name of the village: …………………………Panchayat Block: ………………..

District:…………………….

---

1.Community………………………………………………………………

2.Caste/Tribe (SC/ST/GEN/OBC/Others:………......................................

3.Religion:…………………………………………………………………

4.Sex:………………………………………………………………………

5.Occupational Status:

☐ Government Job ☐ Farmer ☐ Labourer ☐ Teacher ☐ Businessman ☐ Others

**6. Demographic Particulars of the Sample**

| Sl. No. | Name | Relation to Head | Gender | Age | Marital Status | Education | Main Occupation | Subsidiary occupation | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |

7. **Assets Position of the Sample Household**

| Sl.No | Particulars | Number | Approximate Current Value (Rs.) |
|---|---|---|---|
| 1 | **House** | | |
| | Thatched | | |
| | Tin roof | | |
| | Pucca | | |
| 2 | Grain storage house | | |
| 3 | Pumpset | | |
| 4 | Dug wells | | |
| 5 | Tubwells | | |
| 6 | Power thriller | | |
| 7 | Pumpset | | |
| 8 | Threshers | | |
| 9 | Diesel pump | | |
| 10 | Planting Frill | | |
| 11 | TV | | |
| 12 | Radio | | |
| 13 | Cycle | | |
| 14 | 2-wheelers | | |
| 15 | Miller | | |
| 16 | Others (Specify) | | |

**8. Income Particulars**

| **Sl. No.** | **Sources of Income** | **Rs.** |
|---|---|---|
| 1 | Agriculture | |
| 2 | Casual Labour (wage) | |
| 3 | Livestock | |
| 4 | Business/ Trade | |
| 5 | Job/Services | |
| 6 | Others | |
| 7 | Total Annual Income | |

**9. Expenditure Particulars**

| Sl. No. | Particulars | Rs. |
|---|---|---|
| 1 | Food Items | |
| 2 | Clothing | |
| 3 | Medical/ Health | |
| 4 | Education | |
| 5 | Purchase of Farm Implements | |
| 6 | Purchase of Land | |
| 7 | Purchase of Fertilizer | |
| 8 | Purchase of Pesticides | |
| 9 | Electricity for Irrigation Purpose | |
| 10 | HYV Seeds | |
| 11 | Other (Specify) | |

**10. Particulars of Livestock of the Household**

| Sl. No. | Particulars | Number | Total Annual Income |
|---|---|---|---|
| 1 | Bullocks/cow | | |
| 2 | Pigs | | |
| 3 | Buffaloes | | |
| 4 | Poultry | | |
| 5 | Sheep/ Goat | | |
| 6 | Others (Specify) | | |

**11. Land Particulars**

(a) Total Land Owned (Bigha) ………………………………………………………….

(b) Land use for Cultivation (Bigha)…………………………………………………..

(c) Land Put for non-agricultural use including House construction (Bigha)…………

(d) Land lease in (Bigha)……………………………………………………………

(e) Land lease out (Bigha)……………………………………………………………

**12. Land Details (Plot-wise)**

| Plot No. | Name of the Location | Area (Bigha) | Land Quality | Lease Status | Terms of Lease | Sources of Irrigation |
|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

**Note: (3) Land Quality**: Fertile/ Sandy/ Rocky/ Clay, etc. **(4) Lease Status:** Leased in/ Leased out/ Not leased out (own)/ Adi, etc. **(5) Terms of Lease:** Sharecropping (50:50)/Cash Rent (Rs. per Bigha)/Kind Rent/ others **(6) Sources of Irrigation**: Rainfall/ Natural waterways/ Canal/ Tubewell/Dugwell/others.

**13. Availability of Irrigation System**

| Plot No. | Area (Bigha) | Sources of Irrigation | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Rain water | Naturally Flow waterways | Canal | Tubewell | Dugwell | Pumpset | Others |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |

**14. Information on Plot-wise Crops grown in the sample in different Seasons**

(a). Information on Plot-wise crops grown in the sample during **Winter Season**

| Plot No | Area (Bigha) | | Output (Quintal) | | Yield (Kg/Bigha) | |
|---|---|---|---|---|---|---|
| | Traditional | HYV Seeds | Traditional | HYV Seeds | Traditional | HYV Seeds |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |

(b). Information on Plot-wise crops grown in the sample during **Summer Season**

| Plot No | Area (Bigha) | | Output (Quintal) | | Yield (Kg/Bigha) | |
|---|---|---|---|---|---|---|
| | Traditional | HYV Seeds | Traditional | HYV Seeds | Traditional | HYV Seeds |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

(c). Information on Plot-wise crops grown in the sample during **Autumn Season**

| Plot No | Area (Bigha) | | Output (Quintal) | | Yield (Kg/Bigha) | |
|---|---|---|---|---|---|---|
| | Traditional | HYV Seeds | Traditional | HYV Seeds | Traditional | HYV Seeds |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

**15. Information on Productivity of Crops in Different Irrigation Systems**

| Particulars | Area in Bigha | Production | Productivity |
|---|---|---|---|
| Rainwater | | | |
| Naturally Flow waterways | | | |
| Canal Irrigation | | | |
| Tubewell | | | |
| Dugwell | | | |
| Borewell | | | |
| Others (Specify) | | | |

15. **Area, Production and Productivity of Crops in different Seasons with and Without Modern Farm Inputs**

(a) Information on area, production Productivity Crops in **Winter Season**

| Plot No | Traditional Variety with Fertilizer, Pesticides and Irrigation | | | Traditional Variety without Fertilizer, Pesticides and Irrigation | | |
|---|---|---|---|---|---|---|
| | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

(b) Information on Area, Production and Productivity Crops in **Summer Season**

| Plot No | Traditional Variety with Fertilizer, Pesticides and Irrigation | | | Traditional Variety without Fertilizer, Pesticides and Irrigation | | |
|---|---|---|---|---|---|---|
| | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

(c). Information on Area, Production and Productivity of Crops in **Autumn Season**

| Plot No | Traditional Variety with Fertilizer, Pesticides and Irrigation | | | Traditional Variety without Fertilizer, Pesticides and Irrigation | | |
|---|---|---|---|---|---|---|
| | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

**16. Information on Productivity of HYV Crops with and without Modern Farm Inputs in different Seasons**

(a) Productivity of HYV Crops in **Winter Season**

| Plot No | HYV Seeds with Fertilizer, Pesticides and Irrigation | | | HYV Seeds without Fertilizer, Pesticides and Irrigation | | |
|---|---|---|---|---|---|---|
| | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

(b) Productivity of HYV Crops in **Summer Season**

| Plot No | HYV Seeds with Fertilizer, Pesticides and Irrigation | | | HYV Seeds without Fertilizer, Pesticides and Irrigation | | |
|---|---|---|---|---|---|---|
| | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

(c) Productivity of HYV Crops in **Autumn Season**

| Plot No | HYV Seeds with Fertilizer, Pesticides and Irrigation | | | HYV Seeds without Fertilizer, Pesticides and Irrigation | | |
|---|---|---|---|---|---|---|
| | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) | Area in Bigha | Output (Quintal) | Yield (kg/Bigha) |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

**17. Particulars of Agriculture Implements of Household**

| Sl.No | Particulars | No. | Year of Purchase/construction | Cost of purchase | Present value Rs. |
|---|---|---|---|---|---|
| 1 | Steel Plough | | | | |
| 2 | Wooden Plough | | | | |
| 3 | Power tiller | | | | |
| 4 | Bore well | | | | |
| 5 | Tractor used for agriculture | | | | |
| 6 | Bullock cart | | | | |
| 7 | Hand/power spray | | | | |
| 8 | Drip irrigation implement | | | | |
| 9 | Sprinkle irrigation | | | | |
| 10 | Grain cleaner | | | | |
| 11 | Threshers | | | | |
| 12 | Diesel Pumpset | | | | |
| 13 | Others(Specify) | | | | |

**18. The Household Borrowing**

| Sl.No | Sources of Borrowing | Causes of borrowing | Cost (interest) | Amount borrowed | Amount Repaid |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |

Note: Sources of Borrowing= Bank, Individual, Cooperatives, Village Committee, Relatives /Friends, Landlord (rich), traders etc.

**19. Beneficiary of Irrigation schemes from Minor, major and medium, dams Project**

(a) Whether beneficiary of any government irrigation schemes? Yes/No

If yes, name the schemes…………………………………………………

(b) Are you satisfied with the present irrigation system? Yes/No

(c) Do you prefer mode of irrigation? No/Yes, I f yes, why? If no, why?

(i) If yes, because of

☐ Unpredictable rainfall ☐ Irrigation is an alternative source of water

☐ Multiple of cultivation ☐ Satisfactory Productivity ☐ Others

(ii) If no,

☐ Very expensive ☐ No power supply ☐ Environmental problem ☐ others

(d) Is there any demonstration effect for irrigation in the village?. No/Yes,

If yes, which institution?

☐ Irrigation Department ☐ Agricultural Department ☐ Government agency

(e) Did Government proposed any major irrigation Project in the village? Yes/No

If yes name the project…………………………………………………………………

(f) If minor or major project is created in the village? What kind of project it is? Please specify.

☐ Lift irrigation ☐ Surface irrigation ☐ Canal irrigation ☐ Dams

☐ Switch gate ☐ others

(g) Current status of the scheme, is it still functioning? Yes/ No If yes, Why? If no, why?

☐ In use ☐ Temporary not in use ☐ Permanently not in use

(i) If temporary not in use for surface irrigation scheme then, what is the reason?

☐ Non availability of adequate power ☐ Mechanical breakdown ☐ less discharge of water ☐ Storage not filled up fully ☐ Break down of channels ☐ Destroy by flood ☐ no proper canal storage flow ☐ Any other reason…………………

**20. What is reason permanently not in use the irrigation scheme in the village?**

☐ Lack of fund ☐ Negligence ☐ Destroy by flood ☐ damage by erosion

**21. Suggestions of the respondent**

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

**22. Notes or remarks by the investigator/researcher**

# Chapter 4
# General Profile of Sample Households and Study Area

## 4.1 Introduction

In the present chapter, the general profile of the sample villages and households has been described with the help of primary field survey data. More specifically, description of demographic characteristics, occupational structure, land use pattern and the income distribution of sample households are described briefly. Thus, the entire chapter is divided into seven sections. Section 4.2 deals with the demographic characteristics of the sample households. Section 4.3 deals with the occupational structures. In Section 4.4, the income distribution of sample households are given. Further, land related issues such as land holding pattern, land distribution, etc. of the sample households are discussed briefly in Section 4.5. Section 4.6 discusses the utilisation and availability of irrigation among the sample farmers. The Section is the summary of the chapter.

## 4.2. Demographic Characteristics

In this section, we have discussed briefly about the demographic characteristics of sample households such as distribution of sample population according to their social status, age groups, religion, sex, etc.

### 4.2.1 Distribution of Households and Population

As stated earlier, in the present study, total ten villages, namely Hasaobari, Simlaguri, Gopdapara, Gengraypara, Dologaon, Bautipara, Landanguri, Puradia, Baoraguri, and Batabary were selected. These sample villages have been divided into two regions, region 1 and region 2 (for classification of villages see in chapter 3) based on availability of irrigation facilities. The village wise distribution of sample households is presented in Table 4.1. The data provided in the Table 4.1 show us that, there are total 601 persons in 134 sample households in region 1 and 952 persons in 186 sample households in region 2 including children. Thus, there are total 1553 persons in 320 sample households. Out of 1553 sample population, 822 (52.9 percent) are males and 731(47.1 percent) are females. In order to describe the sex wise composition of the population it has been articulated in terms of sex ratio. The average sex ratio of the sample region is 889 which are much lower than all Assam sex ratios (958) and all India level (940)[1]. While we compared the sex ratio of sample district with the Chirang district as a whole it is found that, the sex ratio of the Chirang district as a whole was much higher than the sample region ("Census 2011"). In the sample district the sex ratio is 969 females per 1000 males. In our sample villages Landanguri has the highest sex ratios, which are 1017 females per 1000 males.

Table 4.1: Region-wise distribution of sample villages

| Names of the Villages | Figures are in numbers | | | | Sex Ratio |
|---|---|---|---|---|---|
| | Sample HH | Total Population | Male | Female | |
| Hasaobari | 30 | 129 | 77 | 52 | 675 |
| Simlaguri | 31 | 168 | 90 | 78 | 867 |
| Gopdapara | 12 | 58 | 34 | 24 | 706 |
| Gengraypara | 22 | 84 | 45 | 39 | 867 |
| Dologaon | 39 | 162 | 86 | 76 | 884 |
| **Region 1** | **134** | **601** | **332** | **269** | **810** |
| Bautipara | 28 | 128 | 65 | 63 | 969 |
| Landanguri | 42 | 234 | 116 | 118 | 1017 |
| Puradia | 44 | 263 | 135 | 128 | 948 |
| Baoraguri | 44 | 185 | 97 | 88 | 907 |
| Batabary | 28 | 142 | 77 | 65 | 844 |
| **Region 2** | **186** | **952** | **490** | **462** | **943** |
| **Total** | **320** | **1553** | **822 (52.9)** | **731 (47.1)** | **889** |

Source: Author's calculation from Field Survey Data, 2012

Note: (i) Figures in brackets are percentage to total population in the sample

(ii) The sex ratio is calculated in terms of total females divided by total males X 1000

### 4.2.2 Literacy

The literacy rate among the sample farmers is low (Table 4.2). At the time of calculation of literacy rate, we have excluded children below 6 years of age. There are total 166 children who are below 6 years of age in the sample. Thus, out of 1553 population, only 1437 persons were included in the calculation of literacy rate. Out of 1437 populations, total 835 persons are literate and remaining 602 persons are found to be illiterate. Thus, the literacy rate in the sample is 58.1 percent, which is below the literacy rate of the district as a whole. According to the census report 2011, the literacy rate of Chirang

[1] According to 2011 census report, the sex ratio of Assam as whole was 958 and for all India, it was 940.

district was 63.5 percent. However, the literacy rate among sample population is found to be lower than the literacy rate of Assam state as whole. The literacy rate of Assam is 72.19 percent, according to 2011 census report.

Table 4.2: Educational stutus of sample population

| Regions | No. of Literate Persons | | | Literacy Rate (%) | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total |
| Hasaobari | 53 | 31 | 84 | 63.1 | 36.9 | 65.1 |
| Simlaguri | 59 | 41 | 100 | 59.0 | 41.0 | 59.5 |
| Gopdapara | 27 | 17 | 44 | 61.4 | 38.6 | 75.9 |
| Gengraypara | 29 | 17 | 46 | 63.0 | 37.0 | 54.8 |
| Dologaon | 36 | 27 | 63 | 57.1 | 42.9 | 38.9 |
| **Region 1** | **204** | **133** | **337** | **60.5** | **39.5** | **56.1** |
| Bautipara | 51 | 33 | 84 | 60.7 | 39.3 | 65.6 |
| Landanguri | 62 | 42 | 104 | 59.6 | 40.4 | 44.4 |
| Puradia | 70 | 59 | 129 | 54.3 | 45.7 | 49.0 |
| Baoraguri | 60 | 40 | 100 | 60.0 | 40.0 | 54.1 |
| Batabary | 49 | 32 | 81 | 60.5 | 39.5 | 57.0 |
| **Region 2** | **292** | **206** | **498** | **58.6** | **41.4** | **52.3** |
| **Total** | **496** | **339** | **835** | **59.4** | **40.6** | **58.1** |

Source: Author's calculation from Field Survey Data, 2012

Note: In the calculation of literacy rate:

(1) We have excluded children below 6 years of age.

(2) We have included all the farmers who are able to read and write with understanding in any languages.

Out of total literate persons in the sample, 59.4 percent are males and 40.6 percent are females. Hence, the literacy rate among the females is much lower as compared to male literacy. The female literacy rate in the sample is much lower as compared to 57.9 percent in Chirang district and 63.0 percent in all Assam (2011 census).

### 4.2.3 Age Composition

There are no specific rules for classification of age group. Different scholars have classified persons according to their age groups differently. In our study, we have classified the sample population into four different age groups, i.e., 0-6 as child, 7-15 as a young, 15-59 as an adult and 60 & above as old (Table.4.3). Generally, people under the age group of child (0-6 years) and old age (above 60 years) are un-productive in nature. They are mostly dependent on other productive family members. On the other hand, the adult (15-59 years of age) people are economically the most productive than any other age groups. Therefore, they abide all the responsibility of people belonging to the other age groups.

Table 4.3: Age-wise distribution of sample population

| Name of the Villages | % of persons in different age-groups to total population | | | |
|---|---|---|---|---|
| | 0-6 yrs | 7-15 yrs | 16-59 yrs | 60 & above |
| Hasaobari | 3.4 | 15.8 | 70.6 | 6.6 |
| Simlaguri | 9.1 | 10.2 | 67.8 | 20.9 |
| Gopdapara | 0.7 | 16.0 | 68.1 | 3.3 |
| Gengraypara | 2.7 | 11.6 | 71.3 | 3.3 |
| Dologaon | 8.7 | 12.6 | 74.5 | 4.4 |
| **Region 1** | **24.5** | **66.3** | **70.5** | **38.5** |
| Bautipara | 5.4 | 10.7 | 77.1 | 6.6 |
| Langdanguri | 16.2 | 21.5 | 67.6 | 16.5 |
| Puradia | 10.8 | 21.5 | 76.0 | 20.9 |
| Baoraguri | 8.7 | 18.4 | 72.2 | 13.2 |
| Batabary | 9.4 | 13.6 | 70.1 | 4.4 |
| **Region 2** | **50.5** | **85.7** | **72.6** | **61.5** |
| **Total** | **7.5** | **15.2** | **67.3** | **10.0** |

Source: Author's calculation from Field Survey Data, 2012

On an average, about 67.3 percent of the total population of the sample villages are under the age group of 16-59 years (adult age). This implies that fewer people are dependent on other since many persons are capable of working and earning. Most of the adult age groups in the sample regions are agricultural farmers and they are dependent on agriculture for their livelihood. Agriculture is the main source of employment opportunity in the sample region. Other than agriculture, there are few people who are dependent on business and government jobs.

On an average, about 7.5 percent of the populations are below 6 years of age and about 15.2 percent are between 7-15 years of age. Persons of these two age groups are generally considered to be economically unproductive. These groups of population in the family are considered to be more expensive than other members of the family as they have to spend more not only on food and clothing but also in providing education. Since most of the population under these age groups are school going age, the expenditure incurred on them are high as compared to other age groups. Thus, they are more or less dependent upon the other working population of the family. In addition, about 10 percent population in the sample are old age group. Generally, the age group between 60 and above are termed as old age and most of them too need proper care in terms of medical, fooding, clothing, etc. Thus, they are also considered unproductive population. Similar to below 15 years old children, this age group population are also mostly dependents of other working members of the family. They must be provided with food, clothing and sufficient health cares.

### 4.2.4 Religions

Hinduism, Islam, Christianity, Sikhism and Buddhism are the main religions followed by the people in the sample. Other than above mentioned religions, there are some indigenous religions followed by tribal population in the sample. All the indigenous religions such as Brahma, Bathou, etc. are included in others religion in our study. Bathou and Brahma are the most commonly practiced indigenous religions among the sample households. Most of the Boro community follows these two indigenous religions in the sample. According to a report of 2001 census[2], nearly about 90.31 percent of the Boro Community follows Bathouism, 9.40 percent practice Christianity and 0.29 percent Boro people are believer of the others religion. Owing to less number of sample households under Muslims, Sikhs, Buddhists, etc. religion, these religions are included under other religion in our study. In the sample region, Hinduism is professed by about 38.9 percent of the total population, 32.4 percent believers are Christianity and 28.7 are believers of other religions. Most of the sample households in Dologaon are believers of Hindu religion. On the other hand, the sample households in Hasaobari are followers of other religions rather than Hinduism and Christianity. In addition, about 47.7 percent sample households in Gopdapara are Christian religion believers.

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[2] Report of 2001 census and Boro Bathou religion is an indigenous religion which was worshipped since ancestral, [see Col. Ved Prakash (2007), *Encyclopaedia of Northeast India*, Atlantics Publishers, New Delhi.

Table 4.4: Religion-wise distribution of samplehouseholds

| Villages | Percentage of sample households | | | |
| --- | --- | --- | --- | --- |
| | Total HH | Hindu | Christian | Others |
| Hasaobari | 30 | 26.2 | 15.3 | 58.5 |
| Simlaguri | 31 | 34.8 | 45.2 | 20.0 |
| Gopdapara | 12 | 33.3 | 47.7 | 19.0 |
| Gengraypara | 22 | 41.5 | 17.8 | 40.6 |
| Dologaon | 39 | 55.4 | 25.6 | 19.0 |
| **Region 1** | **134** | **38.3** | **30.3** | **31.4** |
| Bautipara | 28 | 41.4 | 29.6 | 29.0 |
| Langdanguri | 42 | 46.2 | 26.8 | 27.0 |
| Puradia | 44 | 38.2 | 31.8 | 30.0 |
| Baoraguri | 44 | 34.5 | 42.5 | 23.0 |
| Batabary | 28 | 37.1 | 41.9 | 21.0 |
| **Region 2** | **186** | **39.5** | **34.5** | **26.0** |
| **Total** | **320** | **38.9** | **32.4** | **28.7** |

Source: Author's calculation from Field Survey Data, 2012

Note: "Others" includes Buddhists, Muslim, Sikhs, Brahma, Bathou, etc.

### 4.2.5 Community

The distribution of sample households according to their social groups is also presented in Table 4.5. The sample households are classified into two main groups- Boro and others. Since very few other communities live in our sample region, it has been incorporated as one community called “others” in our study. Other communities comprise of Nepali, Santhali, Adivasi, Bengali, Garo, Rajbanshis, etc. Bodo community constitutes the majority of the sample. On an average, about 84.2 percent of the sample population belongs to Bodo community and only 14.4 percent belong to other communities. The region-wise distribution of sample households in terms of their social groups shows that 96.3 percent sample households in region 1 and 81.3 percent households in region 2 are from the Boro community. Only 3.7 percent in region 1 and 18.7 percent in region 2 sample households belong to “others” community in the sample. More than 90 percent households in Hasaobari, Gopdapara, Simlaguri and Gengraypara villages are from the Boro community in region 1. Similarly, more than 80 percent sample households in Batabary, Langdanguri and Bautipara are from the Boro community in region 2.

Table 4.5: Community-wise distribution of sample households (%)

| Villages | Total HH | Bodo | Others |
|---|---|---|---|
| Hasaobari | 30 | 90.2 | 9.8 |
| Simlaguri | 31 | 96.8 | 3.2 |
| Gopdapara | 12 | 96.7 | 3.3 |
| Gengraypara | 22 | 91.3 | 8.7 |
| Dologaon | 39 | 89.7 | 10.3 |
| **Region 1** | **134** | **93.0** | **7.1** |
| Bautipara | 28 | 89.1 | 10.9 |
| Langdanguri | 42 | 88.1 | 11.9 |
| Puradia | 44 | 38.6 | 61.4 |
| Baoraguri | 44 | 79.5 | 20.5 |
| Batabary | 28 | 82.1 | 17.9 |
| **Region 2** | **186** | **75.5** | **24.5** |
| **Total** | **320** | **84.2** | **15.8** |

Source: Author's calculation from Field Survey Data, 2012

Note: "Others" includes Nepali, Santhali, Adivasi, Garo, Rajbongsi, etc.

### 4.2.6 Occupational Structure

The economy of Assam is mainly based on agriculture. Thus, most of the population depends on agriculture sector for their livelihood. According to the 2011 census, about 75 percent of population of Assam was engaged in agricultural sector directly or indirectly as their main occupation. Thus, agriculture sector alone provides employment for 75 percent of the state's population. Very few people of Assam depend on other sectors like industry, service, etc. Accordingly, the sample population of the present study is also mostly dependent on agriculture for their livelihood. The economy of sample region is predominately agrarian in nature. The main occupation of the sample households is agriculture related activities. Out of total 1553 sample population, 589 are working population and 964 are non-working population in the sample. This non-working population includes students, housewives, old age persons and infant population. Of the 37.9 percent working population, on an average about 68.8 percent are farmers. This shows that out of a total population about 26.1 percent are engaged in agricultural activities in the sample. This implies that more than 68 percent sample population is dependent on agriculture. Thus, it shows that agriculture plays an important role in the social and economic development of the sample population by contributing employment to more than 68 percent population. On the other hand, there are some households who earn their livelihood by engaging themselves in other activities such as services, small business, etc. On an average, about 31.2 percent working population in the sample are engaged on these activities.

The region-wise distribution of workforce according to their occupation is also presented in Table 4.6. Both the regions have households more dependent on agriculture than other income earning activities. In region 1, about 69.0 percent households earn their livelihood from agricultural activities. On the other hand, about 68.6 percent sample households in the sample region 2 are dependent on agriculture for their livelihood. On an average only about 68.8 percent are solely dependent on agriculture related activities.

Table 4.6: Occupational distribution of sample population

| Main Occupation | No. of Persons | | | As % to Total Sample | |
|---|---|---|---|---|---|
| | Region 1 | Region 2 | Total | Population | Workers |
| Cultivation | 163 | 203 | 366 | 23.6 | 62.1 |
| Agri Labourer | 26 | 13 | 39 | 2.5 | 6.6 |
| A.Agriculture worker | 189 (69.0) | 216 (68.6) | 405 (68.8) | 26.1 | 68.8 |
| Small Business | 9 | 22 | 31 | 2.0 | 5.3 |
| Service | 76 | 77 | 153 | 9.9 | 26.0 |
| B. Non-agri worker | 85 (31.1) | 99 (31.4) | 184 (31.2) | 11.9 | 31.2 |
| Total workers (A+B) | 274 (45.6) | 315 (33.1) | 589 (37.9) | 37.9 | 100.0 |
| Student | 140 | 337 | 477 | 30.7 | |
| Housewives | 162 | 226 | 388 | 25.0 | |
| Others | 25 | 74 | 99 | 6.4 | |
| Total | 601 | 952 | 1553 | 100.0 | |

Source: Author's calculation from Field Survey Data, 2012

Note: 'Others' refers to the population who are below 5 years old and above 60 years of age

On the other hand, about 31.1 percent in region 1 and 31.4 percent in region 2 are dependent on non-agricultural activities such as small business, service, etc. in the sample. Thus, on an average about 31.2 percent population is dependent on non-agricultural work in the sample. This shows that more than 60 percent of the sample population are directly or indirectly dependent on agriculture sector in the sample.

Sex-wise distribution of sample workers is presented in Table 4.7. It shows that about 69.9 percent working population are males and only 30.1 percent are female population in the sample. The study further shows that more male workers are engaged in agricultural activities as compared to female. Out of total working population, about 76.5

percent male workers are engaged in agricultural activities and only 23.5 percent are female workers. On the other hand, about 44.6 percent female and 55.4 percent males are engaged in other activities like small business and service sector.

Table 4.7: Sex-wisedistribution of working population

| Main Occupation | No. in persons | | % of working Population | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Cultivation | 288 | 78 | 78.7 | 21.3 |
| Agri Labourer | 22 | 17 | 56.4 | 43.6 |
| A.Agriculture Worker | 310 | 95 | 76.5 | 23.5 |
| Small Business | 13 | 18 | 41.9 | 58.1 |
| Service | 89 | 64 | 58.2 | 41.8 |
| B. Non-agri Worker | 102 | 82 | 55.4 | 44.6 |
| Total Workers (A+B) | 412 | 177 | 69.9 | 30.1 |

Source: Author's calculation from Field Survey Data, 2012

Note: "Service" includes both government and private service holder

### 4.2.7 Subsidiary Occupations

Along with the main occupation, many people take up another subsidiary occupation to boost up their earnings. In sample villages also, such activities are found. Many sample farmers, along with their main occupations are engaged in other activities during off seasons. These subsidiary occupations can of different types depending upon the nature of their main occupations. Different subsidiary occupations engaged by farmers in the sample are presented in Table 4.8. Out of total 589 persons, 221 persons are engaged in subsidiary occupations.

Table 4.8: Subsidiary occupations of sample workers

| Subsidiary Occupations | No. of Persons | | | As % to total Sample | |
|---|---|---|---|---|---|
| | Region 1 | Region 2 | Total | Population | Workers |
| Cultivation | 19 | 45 | 64 | 4.1 | 29.0 |
| Agri Labourer | 11 | 20 | 31 | 2.0 | 14.0 |
| A. Agri workers | 30 | 65 | 95 | 6.1 | 43.0 |
| Business | 29 | 78 | 107 | 6.9 | 48.4 |
| Contractor | 0 | 1 | 1 | 0.1 | 0.5 |
| Driver | 4 | 5 | 9 | 0.6 | 4.1 |
| NGO | 2 | 3 | 5 | 0.3 | 2.3 |
| Pastor | 3 | 0 | 3 | 0.2 | 1.4 |
| Teacher | 0 | 1 | 1 | 0.1 | 0.5 |
| B. Non-agri workers | 38 | 88 | 126 | 8.1 | 57.0 |
| Total workers (A+B) | 68 | 153 | 221 | 14.2 | 100.0 |

Source: Author's calculation from Field Survey Data, 2012

Workers who are engaged in the service sector and who are engaged in small business also do perform agricultural activities to boost their income level. About 95 persons (42.3 %) sample workers take up such activities in the sample. About 126 sample workers, which account for about 57.1 percent sample workers take up non-agricultural activities like small business, contractor, driver, work in NGOs, pastor, part time teacher, etc. during off season. Of these, about 43.0 percent are engaged in small business, 4.1 percent are engaged in driving, 2.3 are engaged in NGOs and 1.4 percent is engaged in pastor job and so on. Thus, it is clear that almost every family in the samples are taking up subsidiary occupation to support and reinforce their respective families' income.

### 4.2.8 Annual Income of the Sample

An individual earned income from various sources. These sources can be classified under farm income and non-farm income. Generally, the farm-income is generated from agricultural activities. On the other hand, the non-farm income can be generated from the service sector and other activities. Other than these two income sources, farmers generally adopt certain subsidiary occupations to boost up their incomes (see in the previous section). Some of these occupations are tending labour during off-season, engaging in small business, rearing livestock and so on. Thus, they acquire income from such subsidiary activities. Writing of Bebe et al. (2003) and Moll (2005) said that households adopt different subsidiary occupations to get extra benefit from it. For example, rearing livestock provides wider benefits such as cash income, food, manure, saving and insurance and social status and social capital. As such the study of Mehta and Nambiar (2007) also showed that the landless, marginal and poor poultry farmers keep fewer (7-8) poultry birds to produce eggs for home consumption and to meet one-off expenditures. On the other hand, the wealthier farmers keep larger (over 20,000) broilers for profit motives in India.

Likewise, most of the farmers in the sample take up certain non-farm activities other than agricultural activities and services for upsurge their earning. Thus, in the present study, all the sources of income in the sample are classified into farm and non-farm[3] sources. In addition, there is a growing importance of non-farm activities. Non-farm activities like rearing livestock, engaging in small business, etc. gives immense opportunities to enhance the income of farming communities. It is observed that income earned from the agriculture alone is not sufficient for their daily livelihood. Thus, each household tries to keep dairy farm as well as poultry farm in order to meet their precautionary need and to purchase some agricultural implements. Thus, most of the sample households rear livestock, small business, and other activities along with the main occupation. Livestock rearing gives the higher livelihood in the sample households. This helps the sample population to invest further in agriculture and other allied activities. We have observed that each and every sample household keeps more than 5 domestic animals, 10 poultry and 2 piggeries in their farm. Generally the female member of the family takes care of these livestock rearing activities.

The annual income earned from different sources among the sample is presented in Table 4.9. The study found that earnings from non-farm sector are much higher than farm sector. In other words, most of the sample households earn their income from the non-farm sector. On an average, about 32.4 percent of total income of the sample households is generated from the non-farm sector. Of these, earning from service sector is found to be the highest (55.8 percent) followed by earning by rearing livestock (21 percent) and from small business (7.7 percent). On the other hand, only 11.8 percent income comes from the farm sector in the sample. The annual average income from different sources is also presented in Table 4.9. It is observed that the highest average annual income is derived

[3] The non-farm sources include wage labour, small business, rearing livestock, services (both government and private or part time and full time), etc.

from the service sector. The average annual income from the non-farm sector is Rs. 40488 per household followed by non-farm sector and farm sector. Within the non-farm, earning from rearing livestock recorded to be the highest with Rs.15227 per annum. On the other hand, the average annual income from farm sector was only Rs.8536 per household. This implies that the income derived from the farm sector among the sample households is very less even though large portions of sample households are engaged in farm activities.

Table 4.9: Annual income of sample households from various sources

| Sources of Income | Annual Avg. income (Rs./HH) | | | % of total income | | |
|---|---|---|---|---|---|---|
| | Region 1 | Region 2 | Total Sample | Region 1 | Region 2 | Total Sample |
| **A. Farm Inocme** | **9981** | **7496** | **8536** | **13.0** | **10.8** | **11.8** |
| **B. Services** | **47552** | **35398** | **40488** | **61.9** | **51.0** | **55.8** |
| Wage Labour | 984 | 2171 | 1674 | 1.3 | 3.1 | 2.3 |
| Small Business | 4717 | 6178 | 5567 | 6.1 | 8.9 | 7.7 |
| Livestocks | 12765 | 17001 | 15227 | 16.6 | 24.5 | 21.0 |
| Others | 766 | 1202 | 1020 | 1.0 | 1.7 | 1.4 |
| **C.Total Non-farm** | **19232** | **26553** | **23487** | **25.1** | **38.2** | **32.4** |
| **D.Total (A+B+C)** | **76765** | **69446** | **72511** | **100.0** | **100.0** | **100.0** |

Source: Author's calculation from Field Survey Data, 2012

Note: "Others" includes income earned from miscellaneous sources.

Further, to analyse the income distribution across income groups, we have classified the entire sample population into different income groups according to their annual per capita incomes. Accordingly, the entire sample population is divided into low income, middle income and high income groups (Table 4.10). It is observed that about 61.9 percent sample households are under low income group. The per capita income of low income group is very low as compared to high and middle income groups. On an average, the annual per capita income of low income group is only Rs. 29950 per annum.

Table 4.10: Per capita annaul income of sample households across income groups

| Annual Income Level | % of HH to total Sample | | | Per capita annual income (Rs.) | | |
|---|---|---|---|---|---|---|
| | Region 1 | Region 2 | Total Sample | Region 1 | Region 2 | Total Sample |
| Below 30,000 | 47.8 | 36.6 | 41.3 | 20017 | 20025 | 20054 |
| 30000-50000 | 14.2 | 25.3 | 20.6 | 40142 | 39815 | 39846 |
| Low Income | 61.9 | 61.8 | 61.9 | 30079 | 29920 | 29950 |
| 50000-80000 | 7.5 | 11.8 | 10.0 | 98097 | 64455 | 65015 |
| 80000-100000 | 2.2 | 3.2 | 2.8 | 89367 | 90158 | 90717 |
| Middle Income | 9.7 | 15.1 | 12.8 | 93732 | 77307 | 77866 |
| 100000 & Above | 28.4 | 23.1 | 25.3 | 194355 | 179316 | 186372 |
| High Income | 28.4 | 23.1 | 25.3 | 194355 | 179316 | 186372 |

Source: Author's calculation from Field Survey Data, 2012

In addition, the lowest numbers of households (about 12.2) are found in the middle income group with per capita annual income of Rs.77866 per year. On the other hand, the high income group households constitute about 25.3 percent of the sample. The annual per capita income of this group is Rs. 1, 86371 per annum. The region-wise income distribution of sample households across different income groups also showed that, households with low income group account more than middle and high income groups in both the sample regions. The annual per capita income of low income group households in both the sample regions are also found lower as compared to middle and high income groups. Thus, it is observed that there exists high income inequality in the sample.

### 4.3. Infrastructural Facilities

Infrastructural facilities such as road and transport connectivity, markets, electricity, agricultural credit, etc. are discussed briefly in this section**.**

#### 4.3.1 Road Transport and Communication

As stated in the previous chapter, that the selected district, connected with railway lines and National Highway NH-31. Although there is good connectivity of railways and National Highway, the road transport facilities are not good in any of these sample villages. However, they are found to be peaceful Pucca roads from sample villages to local town, but most of these roads are broken. These Pucca roads are damaged. At present most of these roads are sandstone gravelled only. Moreover, in most of the places, there are no proper bridges to cross the rivers.

#### 4.3.2 Electricity Connection

The electrical connections are available in all the surveyed sample villages. Although the electricity lines are available in the sample villages, but not all sample farmers are connected to electricity owing to many reasons. The electricity connectivity and utilization of sample farmers is presented in Table 4.11. According to our field survey report, out of total sample households, about 262 (81.9 percent) sample households have electricity connectivity. Although there is electricity, connectivity in all sample villages, about 19.1 percent sample farmers were not connected. While asking about not having connectivity of electricity, most of the farmers gave different reasons. Among all the reasons, financial constraint was the main for not having electricity connectivity. Most of them said that they cannot afford its connections. Out of total 262 electricity connected sample households, only 132 households (50.4 percent) were found using for agricultural purposes. However, 50 percent sample families were connected only for domestic uses.

Table 4.11: Electricity connectivity and utilisation in the sample

| Name of the Villages | Electricity Connected | No. of HH | Purpose of Utilisation | | |
|---|---|---|---|---|---|
| | | | Domestic | Agriculture | Both |
| Hasaobari | yes | 21 | 21 | 12 | 12 |
| Simlaguri | yes | 24 | 24 | 10 | 10 |
| Gopdapara | yes | 12 | 12 | 6 | 6 |
| Gengraypara | yes | 13 | 13 | 4 | 4 |
| Dologaon | yes | 23 | 23 | 11 | 11 |
| Bautipara | yes | 29 | 29 | 14 | 14 |
| Landanguri | yes | 40 | 40 | 23 | 23 |
| Puradia | yes | 44 | 44 | 21 | 21 |
| Baoraguri | yes | 39 | 39 | 19 | 19 |
| Batabary | yes | 17 | 17 | 12 | 12 |
| **Total Households** | | **262** | **262** | **132** | **132** |

Source: Field Survey, 2012

### 4.3.3 Agricultural Credit

Credit is said to be one of the most important inputs in agricultural activities. Farmers borrow credit for different reasons and from different sources. Likewise, the sample farmers also borrow money for various reasons. Some farmers borrow money for their personal consumption purpose and some for other productive activities. According to the survey report, about 62.3 percent sample said, they borrow money for consumption purpose like for children's education, for medical, and for other unforeseen expenses. On the other hand, about 37.7 percent sample farmers said, they sometimes borrow money for agricultural activity's purpose. They further said that, they borrow money during the cultivation season for hiring labour, purchasing seeds, fertiliser, pesticides, etc. During dry weather farmers have to use diesel or petrol Pumpset operator to irrigate the field which is very costly.

There are different sources of credit systems which are prevailing in the sample. Most common existing credit sources in the sample regions are Banks, moneylender, village rich, co-operative organisation such as a self help group and other organisations.

For agricultural credit farmers in both the sample regions, mainly depend on informal sources like moneylender, village rich, friends, relatives, traders, etc. Owing to ignorance, the many illiterate farmers do not approach the banks for their credit needs for agricultural activities. Moreover, the banks are not readily available and approachable during their emergency needs. Thus, about 267 sample farmers said that they prefer to borrow credit from informal sources which are readily available in spite of higher interest rate.

During field survey, there were total 187 borrower households in the sample. Out of which 86 were in region 1 and 101 were from region 2. According to reports, about 102 (54.5%) sample borrowers were taking loans from money lenders and 54 (28.9%) from village rich. Moreover, about 16 (8.6 %) sample borrowers borrowed from banks and remaining 15 (8 %) from relatives, friends and other sources.

### 4.4 Agrarian Structure of the Sample

In this section, size of land holding, the pattern of land holding and land distribution system are discussed briefly. As stated above, the sample farmers breed their livelihood from agricultural activities. Thus, agriculture is the most important source of livelihood of the people in the sample region. Rice is the staple food in the sample. Being a staple food, it is grown by almost all the farmers in the sample. Moreover, the agricultural economy of the sample provides employment to more than 60 percent of the sample workers directly and indirectly.

The region has abundant water resources with combination of generous rainfall and fertile land. Water resources such as perennial rivers, streams, springs and ponds are the main sources of water for agriculture in the sample. Villages of region 1 of our study are connected with tributaries of Aie and Makhra River. Thus, these villages have good access to naturally flow waterways for agriculture purpose as compared to region 2. The villages of region 2, on the other hand, have less access to natural flow waterways. The tributaries of the river are far from their field. As a result, they find difficult to connect these water to their fields. Moreover, the depth of the rivers or canal level is much lower than the level of agricultural field in region 2. Thus, region 2 has less water efficiency in terms of filling up water to wet agriculture field during summer and autumn seasons. During these seasons, if they cultivate crops, they have to depend on water pumping from the surface water to make wet the field.

The sample farmers in both regions grow crops mainly in two seasons, i.e. Kharif and Rabi season. The major kharif crops are autumn rice, winter rice, maize, kharif oilseeds and kharif vegetables, etc. They also grow non-food crops like Jute, Mustards, Til, Ginjitil and Mesta, Yam, etc. The winter crops are mostly dependent on rainfall. The majority of the sample households cultivate traditional[4]varieties of rice during winter season. Since rice cultivation in winter season has been gamble of the monsoon most of the farmers do not like to take the risk. Therefore, they prefer to cultivate traditional varieties of rice, especially during winter season. On the other hand, major Rabi crops are also grown in a very vast area in both the sample regions. The Rabi crops grown are summer rice, cereals, grams, mustards, oil seeds and Rabi vegetables. Although, area allocations to Rabi crops are found more in both the sample regions, the actual allocation of area for Rabi rice is very meager. Most of the farmers in the sample grow other crops rather than summer rice owing to lack of water for irrigation. A very few sample farmers grow summer rice owing to lack of irrigation facilities. The main purpose of growing Rabi crops like Mustard oil, Yam, Pulse, Grams, etc. is to meet the crops loses from flood and sudden drought during winter season.

Generally farmers in the sample grow HYV varieties of rice during summer season. Most of the farmers cultivate High Yielding Varieties of rice namely Ranjit, Porimol, Ponkosh, Basmati, etc. during summer season. Generally, most of the farmers cultivate such varieties of rice through Petrol Pumpset, Tubewell, Dug well and partly by naturally flowing waterways since streams remain stagnant for four months after the harvest of winter rice. Most of the farmers, cultivate the summer (Boro) rice in the river basin deltas.

In addition to summer rice, farmers also grow autumn rice in the sample. Both modern and traditional varieties of autumn rice are grown in the sample. But the majority of the sample farmer takes up traditional varieties cultivation instead of modern variety. The main reason of cultivation of traditional autumn rice in the sample is due to lack of proper irrigation facilities. The farmers in sample cultivate autumn rice in both wet and dry agricultural fields.

Winter rice is the most important crop among the sample villages. Most of the sample farmers cultivate winter rice. Since the rainfall is the main source of irrigation for most of the sample farmers, the farmers cultivate winter rice with the help of rain water. Apart from food crops, the farmers grow non-food crops such as Yam (vegetables) and

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[4] *Maisali, Kathikasli, Malsira, Maibra* (Sticky rice), *Bao, Balam*, etc. are the most important traditional rice variety cultivated by the farmers in the sample. All these traditional rice are strong enough and paddy has stamina to stand-up prolong during the flood spelt in rainy seasons.

black grams during this season. The sample farmers do not only grow food crops in their land, but also grow some cash crops and vegetables. Soon after the harvesting season the farmers immediately cultivate some non-food crops like vegetables and mustard seeds, etc. This shows the diversification of crops in the sample.

### 4.4.1 Land Utilisation in the Sample Villages

The total land area of sample region 1 was 322.5 hectares and 443.4 hectares in sample region 2. Thus, the total land area of sample region 1 and region 2 together accounts about 765.4 hectares. Generally, the quality of land is not the same. Some land plots are more fertile[5] than the other and vice-versa. In the sample, some plots are fertile, some plots are loamy[6] and some plots are dry[7]. By and large, most of the plots are found to be fertile in sample villages. Out of total land area, about 675.0 hectares land (88.1 percent) areas are fertile land plots. Of which the fertile land area in region 1 was 281.0 hectares and about 394.0 hectares in region 2 are fertile. The percentage share of fertile land to total land area in region 1 was 87.2 percent and 88.9 percent in region 2. Other than fertile land, about 49.8 hectares land areas were found loamy land. On an average about 12.5 percent in region 1 and 2.2 percent in region 2 were found loamy type of land in the sample respectively. In addition, on an average, dry land area accounts about 5.4 percent of the sample. About 1.2 percent land area out of total land areas were found dry land in region 1 and 8.4 percent in region 2.

Village-wise distribution of land plots is also presented in the Table 4.12. It shows that the Batabary village with 98.6 percent has the highest fertile land as compared to other villages followed by Gopdapara village (94.7 %) and Simlaguri village (92.4 %). On the other hand, Dologaon village has the highest land area under loamy plots as compared to other villages followed by Gengraypara and Hasaobari village. On an average, about 32.9 percent land areas of Dologaon are under Loamy type of land. Similarly, about 18.1 percent land area of Landanguri village is under dry land.

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[5] Fertile plots refers to that quality of land which is rich in nutrients necessary for basic plant nutrition including nitrogen phosphorus and potassium and contains sufficient minerals for plant nutrition including boron, chlorine, cobalt, copper, iron, manganese, magnesium, molybdenum, sulfur, zinc, etc.

[6] Loam is soil composed mostly of sand and silt, and a smaller amount of clay about 40 percent – 40 percent-20 percent concentration, respectively). Generally, loam soils contain more nutrients and moisture.

[7] Dry lands are defined by their scarcity of water. According to UNEP,"dry lands refer to as tropical and temperate areas with an aridity index of less than 0.65".

Table 4.12: Land distribution in the sample

| Name of the Villages | Total Land (Ha) | Land Quality ( in Hectares) | | | % of Total Land | | |
|---|---|---|---|---|---|---|---|
| | | Fertile | Loamy | Dry | Fertile | Loamy | Dry |
| Hasaobari | 76.2 | 68.8 | 8.8 | 1.3 | 90.3 | 11.6 | 1.8 |
| Simlaguri | 80.9 | 74.7 | 3.6 | 2.5 | 92.4 | 4.5 | 3.1 |
| Gopdapara | 62.5 | 59.2 | 3.3 | - | 94.6 | 5.4 | - |
| Gengraypara | 40.3 | 35.6 | 4.7 | - | 88.4 | 11.6 | - |
| Dologaon | 62.7 | 42.7 | 19.9 | - | 68.2 | 31.8 | - |
| Region1 | 322.5 | 281.0 | 40.2 | 3.9 | 87.1 | 12.5 | 1.2 |
| Bautipara | 72.3 | 62.4 | 2.1 | 5.4 | 86.3 | 3.0 | 7.4 |
| Landanguri | 102.5 | 84.1 | - | 18.5 | 82.0 | - | 18.0 |
| Puradia | 103.2 | 91.8 | 5.5 | 5.9 | 89.0 | 5.3 | 5.7 |
| Baoraguri | 98.7 | 90.0 | 2.0 | 6.7 | 91.2 | 2.0 | 6.8 |
| Batabary | 66.7 | 65.7 | - | 0.9 | 98.6 | - | 1.4 |
| Region 2 | 443.4 | 394.0 | 9.6 | 37.2 | 88.9 | 2.2 | 8.4 |
| Total | 765.9 | 675.0 | 49.8 | 41.1 | 88.1 | 6.5 | 5.4 |

Source: Author's calculation from Field Survey Data, 2(

### 4.4.2 Operational Land Holding of Sample Households

Understanding of operational land holdings is essential to understand the agrarian class structure of a community or society. The operational holding is defined as land which is wholly and partially used for agricultural production and operated as a single technical unit by one person alone or with others, without regard to title, size and location[8]. For instance, it may convey the structure of land distribution, level and types or form of tenancy, model and level of agricultural farming and farmers working of local level institutions and so on. Thus, operational holdings are better measures of access to land for production than ownership holdings. The land holding scenario of Assam and national level shows that, a very high portion of the population of the country is either landless or small and marginal land holders. The 59$^{th}$ Round of National Sample Survey (2006a) shows that nearly 6.6 percent of the rural households in India do not own any land. Moreover, about 3.4 percent households have an average of 0.002 hectares. However, according to the agricultural census 2005-06, the average size of land holding in Assam was 1.11 hectares which have slightly decreased to 1.10 hectares[9] in 2010-11.

[8] Agricultural Census, Department of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India.

[9] Economy Survey of Assam, 2014-15 and Agricultural Census 2010-11.

The NSSO[10] classified the land into six broad size classes according to their sizes of land holding. These are nil, marginal, small, semi medium, medium and large. The nil or landless farmers are those farmers who do not have land or operated a land of area not exceeding 0.002 hectares. Moreover, the households who operate 0.002 to 1 hectare are termed as marginal households and who operate 1.01 to 2 hectares of land are small farmers. On the other hand, households who have 2.01 to 10 hectares operational land are considered as medium and above 10 hectares of land are considered as large farmers.

In our study, we have classified the sample farmers into five classes according to their farm size holding (Followed NSSO classification). The semi-medium size of farms is clubbed with medium farm size in our study. The distribution of sample households according to their operational holdings is presented in Table 4.13. The data in Table 4.13 show that, on an average about 12.2 percent sample households are landless. Out of this, about 19.4 percent are from region 2 and only 2.2 percent are from region 1. The study further shows that, the small and marginal farmers dominate the operational holding in the sample. On an average about 27.2 percent is marginal farmers and 38.8 percent are small farmers. The small and marginal farmers together account about 66.0 percent of the total sample population. Of these, 33.6 percent farmers are marginal farmers and 38.1 percent farmers are small farmers in region 1. Similarly, about 22.6 percent are marginal and 39.3 percent are small farmers in region 2. In addition, about 13.4 percent farmers in the sample are medium farmers whose operational holding ranges from 2.0 to 10 hectares. Of these, 15.7 percent belong to region 1 and 10.2 percent are from region 2. Moreover, there are very few farmers whose operational holdings are above 10 hectares in the sample. On an average, there are only 8.4 percent farmers whose operational holdings are above 10 hectares.

[10] The NSSO indicates the National Sample Survey Organisation.

Table 4.13: Operational Land Holding of the Sample Households (in Ha)

| Farm Size | Region 1 | | | | Region 2 | | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No.of HH | % of HH | Land (in Ha) | Avg. holding size (Ha/HH) | No. of HH | % of HH | Land (in Ha) | Avg. holding size (Ha/HH) | No. of HH | % of HH | land (in Ha) | Avg. holding size (Ha/HH) |
| Landless (less than 0.002) | 3 | 2.2 | 0.0 | 0 | 36 | 19.4 | 0.0 | 0.0 | 39 | 12.2 | 0.0 | 0.0 |
| Marginal (0.002-1.00 ha) | 48 | 35.8 | 33.4 | 0.7 | 41 | 22.0 | 42.3 | 1.0 | 87 | 27.2 | 75.8 | 0.9 |
| Small (1.01-2.00 ha) | 47 | 35.1 | 56.5 | 1.2 | 73 | 39.2 | 124.4 | 1.7 | 124 | 38.8 | 180.9 | 1.5 |
| Medium (2.01-10 ha) | 21 | 15.7 | 90.2 | 4.3 | 19 | 10.2 | 168.3 | 8.9 | 43 | 13.4 | 258.6 | 6.0 |
| Large (more than 10 ha) | 15 | 11.2 | 165.2 | 11.0 | 17 | 9.1 | 129.0 | 7.6 | 27 | 8.4 | 294.3 | 10.9 |
| Total | 134 | 100.0 | 345.4 | 2.6 | 186 | 100.0 | 464.1 | 2.5 | 320 | 100.0 | 809.5 | 2.5 |

Source: Author's Calculation from Field Survey Data, 2012

Landless: No operational holding or operational holding of land area less than 0.002 hectares

Marginal: Operational holding of land areas rangom 0.002 -1.00 hectares

Small: Operational holding of land areas ranges from 1.01 hectares -2.00 hectares

Medium : Operational holding of land areas more than 2 .01 hectares to 10 hectares

Large: Operational holding of land areas more than 10 hectares

### 4.4.3 Land Holding Status

The term 'land ownership' is defined as the land, on which the household has the right of permanent, heritable possession with or without the right to transfer the title. The land holding of a farmer/ household can be divided into three categories as presented in Table 4.14. Land can be his/her own land. The land is said to his/ her own land, when the household had the right of permanent, heritable possession with or without the right to transfer the title. On the other hand, land can be leased out[11] or leased in for different purposes. The term leased out is defined that land type of land when a plot of land is leased out to others by the owner without losing the right of permanent heritable possession.[12] In other words, the lease out of land is that land which is given to others on rent or free by the owner of the land without surrendering the right of permanent heritable title.

Table 4.14: Land ownership status of the sample households (in ha)

| Name of the Villages | Own Land | | Leased-out | | Leased-in | |
|---|---|---|---|---|---|---|
| | Hectares | % | Hectares | % | Hectares | % |
| Hasaobari | 73.0 | 84.8 | 9.9 | 11.5 | 3.2 | 3.7 |
| Simlaguri | 79.1 | 85.0 | 12.2 | 13.1 | 1.7 | 1.9 |
| Gopdapara | 56.4 | 77.0 | 10.7 | 14.6 | 6.2 | 8.4 |
| Gengraypara | 35.6 | 83.4 | 2.4 | 5.6 | 4.7 | 11.0 |
| Dologaon | 57.0 | 79.5 | 9.1 | 12.7 | 5.6 | 7.8 |
| **Region 1** | **301.1** | **82.1** | **44.3** | **12.1** | **21.4** | **5.8** |
| Bautipara | 66.5 | 86.1 | 5.0 | 6.4 | 5.8 | 7.5 |
| Landanguri | 94.1 | 73.7 | 25.2 | 19.7 | 8.4 | 6.6 |
| Puradia | 96.7 | 83.0 | 13.3 | 11.4 | 6.6 | 5.6 |
| Baoraguri | 93.4 | 86.3 | 9.6 | 8.9 | 5.2 | 4.8 |
| Batabary | 56.1 | 79.1 | 4.3 | 6.0 | 10.6 | 14.9 |
| **Region 2** | **406.8** | **81.3** | **57.3** | **11.4** | **36.5** | **7.3** |
| **Total (1+2)** | **707.9** | **81.6** | **101.6** | **11.7** | **58.0** | **6.7** |

Source: Field Survey Data, 2012

[11] According to 59th Round NSS report, the lease of ownership may be (a) for fixed money (b) for fixed produce (c) for share of produce (d) for service contract (e) for share of produce together with other terms (f) under usufructuary mortgage (g) from relatives under no specified terms and (h) under other terms. The term by which the mortgagor retained the ownership of land till the foreclosure of the deed but the possession of the land was transferred to the mortgagee would be considered as leasing-out under usufructuary mortgage.

[12] 59th Round NSS report,( Report No. 491 (59/18.1/4), 2003.

On the other hand, the leased in of land means that the land is taken by a household /person on rent or free without any right of permanent or heritable possession. According to data given in Table 4.13, out of total land area in the sample about 92.4 percent lands are owned by farmers themselves. Only 7.6 percent of land area is taken as a lease by sample farmers. On the other hand, out of total land area owned by farmers about 14.4 percent land area is given on lease.

### 4.5 Crops and Cropping Pattern in the Sample

The distribution of land on various crops and the number of land uses in a particular year can be understood by cropping pattern and cropping intensity. It is an important indicator to show the proportion of area under different crops at a definite point of time. The cropping pattern refers to the proportion of area under various crops at any given point of time. On the other hand, cropping intensity is demarcated as "a ratio between "gross cropped areas" "(GCA)" and "net sown area" "(NSA)". Cropping pattern in a region or state may change with the changes in proportion of area under different crops. Cropping pattern plays an important role in agricultural development of a region or a state. It is said that irrigation is the prime factor for multiple cropping pattern. According to Phukan (1990), to increase rice productivity by adopting double and multiple cropping, assured irrigation facility is essential. Low productivity of crops may be largely endorsed to lack of irrigation. "Not only irrigation, the local climatic conditions and topography are also said to have the impact of multiple cropping patterns and hence both production and productivity (Bhattacharya, 1998)". "Moreover, Dutta (2011) found that the cropping pattern of a state or region is also associated with the changes in the economic and technological factor".

The sample farmers grow various crops round the years. Rice is the staple food of the sample region, cultivated in the vast land area. Almost all farmers in the sample cultivate rice crop. Generally, it is observed that, sample farmers grow rice crops in three different seasons. These are known as Sali rice, Boro rice and Ashu rice. On an average of about 62.8 percent gross cropped are in the sample are occupied by rice crop. It is further observed that rice occupied about 70.9 percent of GCA in region 1 and 57.4 percent GCA in region 2. Next to rice, pulse is the major crop grown by the sample farmers. It occupied about 19.1 percent of GCA in the sample. Apart from pulse cultivation, the sample households also do cultivate rapeseed, & mustard in a large area. In total crops area, about 8.6 percent land area is used in cultivation of mustard oil.

Farmers in sample cultivate various vegetables. It occupies about 0.5 percent of the GCA in the sample. Generally, most of the sample farmers cultivated vegetables during Rabi season. The potato, tomato, brinjal, cauliflowers, onion, garlic, pumpkins, cabbage, turmeric, bean, radish, etc, are commonly grown vegetables in the sample region. Almost all the farmers in the sample grow all these vegetables for the family consumption purpose. Farmers in the sample also grow various fruit crops. Some of these fruit crops are pineapple, banana, coconut, pea, guava, orange, etc.

Table 4.15: Cropping pattern in the sample (area in ha)

| Crops | Region 1 | | Region 2 | | Total Sample | |
|---|---|---|---|---|---|---|
| | Area (Ha) | % of GCA | Area (Ha) | % of GCA | Area (Ha) | % of GCA |
| Sali rice | 300.7 | 46.0 | 379.6 | 39.4 | 680.3 | 42.1 |
| Boro Rice | 80.0 | 12.2 | 78.2 | 8.1 | 158.2 | 9.8 |
| Ahsu rice | 82.2 | 12.6 | 95.8 | 9.9 | 178.0 | 11.0 |
| **Total Rice** | **462.9** | **70.9** | **553.6** | **57.4** | **1016.4** | **62.8** |
| Wheat | 0.4 | 0.1 | 6.7 | 0.7 | 7.1 | 0.4 |
| Pulse | 71.7 | 11.0 | 237.1 | 24.6 | 308.8 | 19.1 |
| Mustard oil | 62.0 | 9.5 | 77.4 | 8.0 | 139.4 | 8.6 |
| Blackgram | 0.5 | 0.1 | 0.7 | 0.1 | 1.3 | 0.1 |
| Jute | 28.8 | 4.4 | 20.5 | 2.1 | 49.3 | 3.0 |
| Yam | 1.1 | 0.2 | 16.7 | 1.7 | 17.8 | 1.1 |
| Spices | 1.1 | 0.2 | 13.7 | 1.4 | 14.8 | 0.9 |
| Vegetables | 2.5 | 0.4 | 5.8 | 0.6 | 8.3 | 0.5 |
| Fruits | 0.3 | 0.0 | 2.3 | 0.2 | 2.6 | 0.2 |
| Others | 1.6 | 0.2 | 2.4 | 0.2 | 4.0 | 0.2 |
| Perenial Crops | 20.3 | 3.1 | 27.6 | 2.9 | 48.0 | 3.0 |
| **GCA** | **653.1** | **100.0** | **964.5** | **100.0** | **1617.6** | **100.0** |

Note: "Vegetables" refers to all kinds of Vegetables cultivated in the sample
Source: Same as in Table 4.1

## 4.6 Farm Inputs

The yield of rice per unit of land is influenced by several factors. For example, systematic use of farm inputs such use of fertiliser, HYV seeds, irrigation, pesticides, etc. Moreover, the yield per unit of land also tends to be high when the region is having fertile soil with suitable agro-climatic condition. In the sample, farmers do buy their inputs such as fertiliser; seeds, pesticides, irrigation, labourer, etc. Farmers in the sample purchase inputs like fertiliser, seeds and pesticides from the nearest market. Generally farmers in the sample use more or less traditional seeds, bio-fertiliser, traditional method of irrigation, etc. Only few able farmers in the sample use the modern farm inputs in their crop cultivation.

### 4.6.1 Use of Chemical Fertiliser

The utilisation of chemical fertiliser among the sample farmers in different seasons is presented in Table 4.16. Basically, farmers in the sample villages were found using traditional or manure. Only few farmers were found adopting chemical fertiliser (Urea) in their production. Out of total sample households in region 1 only 35.8 percent households found using chemical fertiliser in kharif crop cultivation and 52.7 percent in Rabi crop cultivation. Likewise, in region 2 also only 36.6 percent were found using chemical fertiliser in Kharif crop and 43.2 percent in Rabi crop cultivation. This indicates that more than 60 percent of farmers use manure in the sample instead of chemical fertiliser in their crop cultivation. Moreover, the area under chemical fertiliser was found to very meagre in the combined sample regions. Out of total gross cropped area, only 216 hectares (28.2%) were brought under the chemical fertiliser during Kharif crop cultivation in the combined sample regions. In addition, only 342.1 hectares Rabi crop areas were brought under chemical fertiliser during our survey period.

Table 4.16: Area under chemical fertiliser in sample

| Villages | Kharif | | Rabi | |
|---|---|---|---|---|
| | No. HH (%) | Area (ha) | No. HH (%) | Area (ha) |
| Hasaobari | 40.0 | 21 | 48.3 | 40.0 |
| Simlaguri | 35.5 | 20 | 51.2 | 36.8 |
| Genraypara | 33.3 | 15 | 64.3 | 18.0 |
| Gopdapara | 36.4 | 12 | 51.5 | 28.2 |
| Dologaon | 33.3 | 17 | 48.5 | 35.1 |
| **Region 1** | **35.8** | **85** | **52.7** | **158.1** |
| Bautipara | 39.3 | 24 | 46.7 | 24.8 |
| Landanguri | 33.3 | 27 | 39.0 | 32.5 |
| Puradia | 38.6 | 32 | 48.1 | 46.4 |
| Baoraguri | 36.4 | 30 | 39.8 | 48.9 |
| Batabary | 35.7 | 18 | 42.6 | 31.4 |
| **Region 2** | **36.6** | **131** | **43.2** | **184.0** |
| **Total** | **36.2** | **216** | **48.8** | **342.1** |

Source: Field Survey Data, 2012

The main reason of being less utilisation of chemical fertiliser was due to excess rain water during winter washed away the costly chemical fertilisers from plot to another plot. Therefore, farmers in the sample are not interested to use the chemical fertiliser which is very costly. Moreover, the farmers in the sample believed that the use of chemical fertiliser destroys the natural fertility of soil. Thus, many farmers prefer to use manure (cow dung) in their cultivation. However, the chemical fertiliser use for paddy recorded to have very less as compared to other crops. It was found that almost all farmers use chemical fertiliser for vegetable crops like cabbage, Potato, Peas, Tomato, etc.

### 4.6.2 Area under HYV

The utilisation of HYVseeds among the sample farmers is presented in Table 4.17. Out of total sample household, about 62.1 percent sample households in region 1 and 60.2 percent households in region 2 use HYVseeds during the study period. The utilisation of HYVseeds during Rabi crop was found more as compared to Kharif crops in both the regions.

Table 4.17: Area under HYV seeds in sample

| Villages | Kharif | | Rabi | |
|---|---|---|---|---|
| | No. HH (%) | Area (ha) | No. HH (%) | Area (ha) |
| Hasaobari | 23.2 | 28.2 | 36.3 | 35.2 |
| Simlaguri | 26.5 | 26.4 | 35.9 | 33.1 |
| Genraypara | 20.3 | 23.2 | 38.6 | 10.3 |
| Gopdapara | 26.6 | 20.6 | 42.8 | 25.6 |
| Dologaon | 23.3 | 25.3 | 36.5 | 34.7 |
| **Region 1** | **24.0** | **123.7** | **38.1** | **138.9** |
| Bautipara | 29.6 | 34.0 | 33.4 | 25.8 |
| Landanguri | 24.4 | 31.7 | 35.0 | 29.2 |
| Puradia | 28.4 | 34.1 | 35.1 | 42.3 |
| Baoraguri | 26.6 | 33.4 | 30.6 | 40.6 |
| Batabary | 25.4 | 28.9 | 32.4 | 28.1 |
| **Region 2** | **26.9** | **162.1** | **33.3** | **166.0** |
| **Total Sample** | **25.5** | **285.8** | **35.7** | **304.9** |

Source: Field Survey Data, 2012

Moreover, the area under HYV seeds was found higher in Rabi season than Kharif season. About 304.9 hectares land was brought under HYV seeds during Rabi season in the combined sample as against 285.8 hectares in Kharif season. The excess water during kharif season creates problem to the High Yielding Varieties crops since most of them are short. In Kharif season, especially in Region 1, heavy rainfall creates excess water. Owing to this, the short varieties HYV crops stay under water and these crops are damaged. Thus, most of the farmers in sample cultivate traditional varieties of crops during kharif season.

### 4.6.3 Mechanisation

Now-a-days, utilisation of tractor and power tiller for tilling the land became very familiar among the farming community. Although, the utilisation rate among the sample farmers were found very negligible. The adoption of tractors and power tiller in the sample is presented in Table 4.18. Only 29.4 percent sample households were found adopting tractor and power tiller to till their land during the study period. Out of which 26.9 percent were from Region 1 and 31.2 percent were from Region 2. Moreover, only 16.7 percent, out of total GCA were ploughed by modern farm equipments in the sample during study period. However, few farmers were also found using the threshing machine in the sample.

Table 4.18: Adoption of tractor and power tiller in crop cultivation

| Villages | Ploughing by Tractor and Power | | % of total HH | % of GCA |
|---|---|---|---|---|
| | No. HH | Area (ha) | | |
| Hasaobari | 6 | 8.0 | 20.0 | 10.5 |
| Simlaguri | 4 | 11.7 | 12.9 | 14.4 |
| Genraypara | 9 | 13.2 | 75.0 | 21.1 |
| Gopdapara | 7 | 8.6 | 31.8 | 21.3 |
| Dologaon | 10 | 11.2 | 25.6 | 17.9 |
| **Region 1** | **36** | **52.7** | **26.9** | **16.3** |
| Bautipara | 7 | 14.8 | 25.0 | 20.5 |
| Landanguri | 9 | 18.4 | 21.4 | 17.9 |
| Puradia | 14 | 22.2 | 31.8 | 21.5 |
| Baoraguri | 17 | 10.4 | 38.6 | 10.5 |
| Batabary | 11 | 9.6 | 39.3 | 14.4 |
| **Region 2** | **58** | **75.4** | **31.2** | **17.0** |
| **Total Sample** | **94** | **128.1** | **29.4** | **16.7** |

Source: Field Survey Data, 2012

### 4.6.4 Pesticides and Insecticides

Usually, only a few farmers in the sample were found using pesticides. The use of pesticides and insecticides were found negligible in the sample as compared to High Yielding Varieties crops and fertiliser. Out of total sample only 138 farmers were found using pesticides in their crops. And most of them were found using in vegetable cultivation, such as tomato, potato, Cabbage, green peas, cauliflower, etc. Since green vegetables are prone to insects and very sensitive, farmers spray insecticides to protect them from different insects.

### 4.6.5 Irrigation

Generally, farmers in the sample are mostly dependent on naturally flowing waterways and rain water for irrigation. During winter season, rainfall becomes the main source of irrigation for crop cultivation. The heavy rainfall during winter season rejuvenates the stream and hence naturally flowing waterways. Hence, rain water and naturally flowing water ways serve as the main source of especially in Region 1. Besides, rainfall and natural flow waterways, the farmers in the sample also use Pumpset, Tubewell, Dugwell, Borewell, etc. especially during dry season. Due to less rainfall during summer and autumn season, the natural flow waterways from rivers reduced considerably. As a result, many stream dried out. Thus, to grow crops during the autumn and summer season many farmers use Pumpset machine to extract water.

Local irrigation systems have been handed down through generation becoming a tradition in rural area where household farmers design, small dam on landscape from the springs which is a reliable source of water to the entire villages. Dams and pond are the vital source to cater the basic need of water in the region. In the sample villages, farmers construct small tangible dams to reduce water logging and overflowing of water. Thus, this reduces the dependency of farmers on rainfall and enabling them to provide water for irrigation. Generally, this type source of water is extracted from a river which is perennial in nature. To access this water a weir or stream is constructed across Perennial River. Besides construction of a weir or stream, sometimes dam may be constructed to form a reservoir upstream. Further, to extract water, the main canal with a regular is constructed where one or both banks supply to the crop field. These types of water resources are reliable as water is available round the years.

In the sample, they have small dams which were constructed in concrete cement for about 7 meters. On the other hand, most of the villages have a small pond near the agricultural field for the use of shocking jute after the harvest. This pond does not dry up early, but remain stagnant for three to four months after the rainy season. The sample villages which are situated near the dams and pond uses these water for cultivation, both in summer and autumn season. Thus, dam irrigation also acts as a source of irrigation during summer and autumn rice cultivation. Ponds are individually owned with no community involvement.

In addition, there are also dongs (canal type) systems of irrigation in the sample. It is a traditional artificial recharge practice by household farmers in the sample villages. Dong (inundation channels) are created long channel from the main tributaries or Perennial River by constructing a small dam on the head to divert runoff water to the agricultural field. In other word, dongs are pond constructed to harvest water for irrigation. Ponds are small irrigation channels linking rice fields to stream. Generally, the current of water runoff from Perennial River is fast to connect in to the field. Thus, to slow down over the head on the Dong, people usually construct small dams. Since, all the sample villages are not availing the same perennial river flow as mentioned in the previous section, the sample villages of region 2 have to wait for monsoon season to get spring up water from Dong. They have to construct a pond or dighi to evaporate spring water for storage. This is also known as Dong or Dongo system. The Dong system is traditionally prevalent among the sample villages which ensure provision of water for mainly wet paddy cultivation especially for Sali rice. It is very much helpful in higher altitude, soil where water retention capacity is low and rainwater is not sufficient.

### 4.7 Summary

The main purpose of this chapter was to describe the general profile of sample households. Main points described here were demographic characteristics, occupational structures and land holdings of the sample regions. It is observed that the literacy rate in the sample region was low as compared to the national and state level. Majority of the sample farmers continue to depend on agriculture sector. That is, almost all farmers are mostly dependent on agriculture sector for their livelihood. Although agriculture is the backbone of the sample farmers, most of the farmers (about 68 percent) are found to be marginal and small farmers. There exists high inequality in land distribution and income distribution among the sample farmers. The study of cropping pattern in the sample shows that rice, being the major food crop, is occupying about 62.8 % of GCA. The farmers in the sample also grow other food crops, vegetables, fruit, spices etc.

With this background, we proceed to examine the irrigation development and utilisation of availability source of irrigation of sample villages in the next chapter.

Table 4.13: Operational land holding of the sample households (in ha)

| Farm Size | Region 1 | | | | Region 2 | | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No.of HH | % of HH | Land (in Ha) | Avg. holding | No. of HH | % of HH | Land (in Ha) | Avg. holding size (Ha/HH) | No. of HH | % of HH | land (in Ha) | Avg. holding size (Ha/HH) |
| Landless (less than 0.002) | 3 | 2.2 | 0.0 | 0 | 36 | 19.4 | 0.0 | 0.0 | 39 | 12.2 | 0.0 | 0.0 |
| Marginal (0.002-1.00 ha) | 48 | 35.8 | 33.4 | 0.7 | 41 | 22.0 | 42.3 | 1.0 | 87 | 27.2 | 75.8 | 0.9 |
| Small (1.01-2.00 ha) | 47 | 35.1 | 56.5 | 1.2 | 73 | 39.2 | 124.4 | 1.7 | 124 | 38.8 | 180.9 | 1.5 |
| Medium (2.01-10 ha) | 21 | 15.7 | 90.2 | 4.3 | 19 | 10.2 | 168.3 | 8.9 | 43 | 13.4 | 258.6 | 6.0 |
| Large (more than 10 ha) | 15 | 11.2 | 165.2 | 11.0 | 17 | 9.1 | 129.0 | 7.6 | 27 | 8.4 | 294.3 | 10.9 |
| Total | 134 | 100.0 | 345.4 | 2.6 | 186 | 100.0 | 464.1 | 2.5 | 320 | 100.0 | 809.5 | 2.5 |

Source: Author's calculation from Field Survey Data, 2012

Landless: No operational holding or operational holding of land area less than 0.002 hectares

Marginal: Operational holding of land areas rangom 0.002 -1.00 hectares

Small: Operational holding of land areas ranges from 1.01 hectares -2.00 hectares

Medium : Operational holding of land areas more than 2 .01 hectares to 10 hectares

Large: Operational holding of land areas more than 10 hectares

# Chapter 5
# Availability and Utilisation of Irrigation: Field Level Observations

## 5.1 Introduction

In this chapter, an attempt has been made to examine the availability and utilisation of irrigation mainly for paddy crop in the sample households with the help of field survey data. Due to the heterogeneous characteristics of farmers, the extent of irrigation availability varies across households and land plots. Thus, the main objective of this chapter is to examine the extent of provision, utilisation and benefits of different types of irrigation systems among the sample households in the Chirang district of Assam. The primary data were collected during January-April 2012 and November-December 2012 through structured questionnaires/field survey form. Accordingly, the entire chapter has been divided into four sections. Availability and accessibility of irrigation in the sample are examined in Section 5.2. The source-wise utilisation of available irrigation across in the sample is discussed in Section 5.3. The seasonal utilisation of available irrigation among sample farmers is analysed in Section 5.4. The various possible factors which are responsible for poor irrigation system in the sample region are examined in section 5.5. The last Section 5.5 gives the summary of the chapter.

## 5.2 Irrigation Availability in the Sample

As stated in the previous chapter (section 4.6.5), rainfall and naturally flowing water ways are the main sources of irrigation in the sample. These sources of irrigation are generally not perennial. The rainwater and naturally flowing waterways serve only for some months of the year (June-July to September-October months). Thus, remaining months become almost dry in the sample. During dry months, most farmers in the sample cultivate crops which required less water. Crops like paddy (direct seedling) locally known as *Mai Gwran*, mustard, wheat, Jute and vegetables are commonly cultivated during dry season.

Moreover, utilisation of modern irrigation equipments such as Pumpset, Tubewell, Borewell are also found among the sample. Thus, in our present study, we have classified the availability of irrigation systems into rainwater, naturally flowing waterways, Pumpset (diesel or electric), Tubewell, Borewell and Dugwell.

### 5.2.1 Different Irrigation Systems in the Sample

In the sample regions, generally farmers do not have any systematic irrigation system. Thus, almost all farmers are mostly dependent on rainwater and naturally flowing waterways for paddy cultivation. The rainwater and naturally flowing waterways such as river tributaries, stream, and springs water are the main sources of irrigation in the sample. Irrigation by means of small dams on naturally flowing waterways and underground water serve as the main source of irrigation for cultivation especially during winter season. The naturally flowing waterways such as tributaries of river, stream, springs, water is directly lifted by a lift irrigation system which is constructed by farmers collectively. In this system, water is generally lifted by constructing earthen dam directly from river, stream and springs. More specifically, farmers in sample region 2 are heavily dependent on rainwater and naturally flowing waterways for paddy cultivation. On an average about 76.1 percent of sample region 2 are dependent on natural flowing waterways and 37.3 percent are on rainwater for their crop cultivation.

On the other hand, the dependent on rainwater is more in region 1 as compared to on naturally flowing waterways. The main reason for less dependent on natural flowing waterways in region 2 was due lack of water of major tributaries nearby to their villages. The villages in region 2 are located very far away from Makhra and Aie the major tributaries of the district. As a result, they are more dependent on rainwater, especially during winter crop cultivation. According to data presented in Table 5.1, about 74.7 percent of the sample farmers depend on rainwater for their paddy crop cultivation. Only 25.3 percent of sample households are able to use naturally flow waterways for crop cultivation in region 2 during the study period. In winter season, owing to heavy rainfall, the water of these two tributaries goes up and overflows to other parts of the district. The overflowing due to heavy rain also serves other parts of the district. On an average, about 49.1 percent sample farmers are dependent on natural flowing waterways and 59.1 percent are on rain water for crop cultivation in the combined sample region.

On the other hand, the field survey also found the presence of modern irrigation equipments like Pumpsets, Borewells and Tubewells in the sample villages. The village-wise number of irrigation equipment available in the sample is presented in Table 5.2. There were 164 pumpsets, 26 Borewells and 33 Tubewells in the combined sample region. Since villages, in region 1 are more prone to tributaries, the utilisation of Pumpsets, Borewells and Tubewells irrigation was found less. Whatever they own was to use during summer and autumn season. Most of them use the naturally flowing waterways for crop cultivation. Out of 164 pumpsets, there were only 74 pumpsets, 10 Borewells and 15 Tubewells in region 1. On the other hand, most of the farmers (those who own more dry land) were observed to own pumpsets in region 2. Generally, farmers in region 2 use those pumpsets, Borewells and Tubewells irrigation even during winter season depending upon the degree of rainfall. If there is low rainfall, they solely depend on the Pumpsets, Borewells, and Tubewells irrigation for paddy cultivation.

Table 5.1: Source-wise irrigation use in the sample

| Sources of Irrigation | Region 1 | | Region 2 | | Total Sample | |
|---|---|---|---|---|---|---|
| | No. of HH | % of total sample HH | No. of HH | % of total sample HH | No. of HH | % of total sample HH |
| Rainfed | 50 | 37.3 | 139 | 74.7 | 189 | 59.1 |
| Naturally flow waterways | 110 | 82.1 | 47 | 25.3 | 157 | 49.1 |
| Tubewell | 15 | 11.2 | 21 | 11.3 | 36 | 11.3 |
| Dugwell | 14 | 10.4 | 15 | 8.1 | 29 | 9.1 |
| Pumpset | 45 | 33.6 | 52 | 28.0 | 97 | 30.3 |
| Borewell | 11 | 8.2 | 9 | 4.8 | 20 | 6.3 |

Source: Field Survey Data, 2012

Data in Table 5.2 further show that there were 266 Dugwells in the combined sample region. Although there are large numbers of Dugwells in the sample, the utilisation of Dugwells for agriculture purposes were found less. Most of the farmers in the sample used these Dugwells for domestic consumption purposes and not for crop cultivation. Thus, it is observed that on an average only about 9.1 percent (29 households) sample households use the Dugwells for agricultural practices in the sample. The less utilisation of Pumpsets, Borewells and Tubewells irrigation in the sample is due to the cost of utilisation. The utilisation of such irrigation system is a costly service. Hence, only 59 farmers of middle income and 105 high income group farmers were adopting these irrigation systems in entire sample villages. It is further found that, almost all the users of such irrigation system were using these equipments only during the summer and autumn seasons.

Table 5.2: Number of irrigation equipments in sample

| Villages | Pumpsets | Borewells | Dugwells | Tubewells |
|---|---|---|---|---|
| Hasaobari | 15 | 2 | 24 | 2 |
| Simlaguri | 20 | 1 | 22 | 3 |
| Gopdapara | 7 | 3 | 9 | 1 |
| Gengraypara | 11 | 1 | 18 | 4 |
| Dologaon | 21 | 3 | 34 | 5 |
| **Region 1** | **74** | **10** | **107** | **15** |
| Bautipara | 13 | 3 | 23 | 2 |
| Landanguri | 21 | 5 | 37 | 4 |
| Puradia | 18 | 2 | 37 | 6 |
| Baoraguri | 23 | 4 | 39 | 2 |
| Batabary | 15 | 2 | 23 | 4 |
| **Region 2** | **90** | **16** | **159** | **18** |
| **Total** | **164** | **26** | **266** | **33** |

Source: Field Survey Data, 2012

Although, farmers owned Dugwells, Tubewells, Pumpsets, and Borewells in the sample the utilisation of such irrigation equipments is very less. More specifically, these equipments were used only during summer and autumn season. In dry seasons like in autumn and summer, the water level of the stream and tributaries goes down and dry up. As a result, the farmers are unable to use naturally flowing water for paddy cultivation. Owing to this reason, the farmers in the sample are compelled to explore the groundwater irrigation through Dugwells, Tubewells, Pumpsets, and Borewells. Accordingly, about 33.6 percent households in region 1 and 38 percent households in region 2 are found using pumpsets irrigation. But most of the farmers in region 1 were found using pumpsets only during Rabi paddy cultivation. On an average about 35.8 percent sample farmers were found adopting Pumpset irrigation in the combined sample regions. In addition, about 11.2 percent and 14.6 percent households were found adopting Tubewells irrigation in region 1 and region 2 respectively. Thus, about 12.9 users of Tubewell irrigation were found in the combined sample regions. Moreover, there were 13.6 percent Dugwell and 9.5 percent Borewell users in the combined sample region during the study period (Table 5.1).

### 5.2.2. Area under Different Irrigation System

It is seen (in the previous section) that there are no systematic irrigation systems in both the sample regions. Systematic irrigation systems such as canal irrigation, switch-gate irrigation, etc. were found to be nil in the sample regions. Thus, the gross cropped areas are served only by naturally flow waterways, rainfall and partly by modern irrigation equipments such as Pumpset, Tubewell and Borewell. Table 5.3 shows the source-wise distribution of irrigated areas in sample regions. The largest crop areas of 108.7 hectares (61.2 %) are served by naturally flow waterways in region 1. On the other hand, about 61.2 hectares (13.8 %) are served by naturally flow waterways in region 2. Thus, on an average about, 169.9 hectares (22.2 %) out of total gross cropped areas were served by naturally flow waterways in the combined sample regions.

Besides, about 13.1 percent areas were irrigated by pumpset irrigation in the combined sample regions. Of which 15.2 percent were in region 1 and 11.8 percent were in region 2. Moreover, about 3.2 percent and 3.4 percent areas were irrigated by Borewell and Tubewell respectively during the study period. However, the area under Dugwell irrigation was found very low in the combined sample. During the study period, the area under Dugwell irrigation was only 2.6 percent of gross cropped area.

Table 5.3: Area under different sources of irrigation in the sample

| Sources | Area in ha | | | Percentage | | |
|---|---|---|---|---|---|---|
| | Region 1 | Region 2 | Total | Region 1 | Region 2 | Total |
| Naturally flow waterways | 108.7 | 61.2 | 169.9 | 33.7 | 13.8 | 22.2 |
| Tubewells | 12.2 | 14.0 | 26.3 | 3.8 | 3.2 | 3.4 |
| Dugwells | 8.7 | 11.5 | 20.2 | 2.7 | 2.7 | 2.6 |
| Pumpsets | 49.2 | 51.1 | 100.3 | 15.2 | 11.8 | 13.1 |
| Borewells | 9.1 | 15.2 | 24.3 | 2.8 | 3.5 | 3.2 |

Source: Field Survey Data, 2012

The low utilisation of pumpsets, Borewell and Tubewell irrigation systems was due to the high cost involved in the installation. Generally the groundwater level in both the regions is comparatively low. Although the groundwater level is moderately low, for effective discharge of water, it is necessary to put water pipe about 20 to 25 meters in the ground. As a result, installation of such irrigation system involves high cost. Owing to high costs involved in groundwater irrigation system, only few small and marginal farmers in the sample could use it. Thus, it was found that, groundwater irrigation is mostly used in summer and autumn seasons only in the sample. Moreover, the erratic supply of electricity is another factor for not using such irrigation equipments. Owing to irregular electric supply most of the farmers used diesel Pumpset in the sample. Thus, the small and marginal farmers in the sample are not able to use the high cost diesel operated pumpsets.

### 5.2.3 Total Irrigated area to GCA

The total gross cropped area in divided into irrigated and un-irrigated in our study. The irrigated areas are further classified under irrigated by naturally flow waterways and modern irrigation equipments. The area under irrigation to GCA is presented in Table 5.4. On an average about 43.9 percent land areas were found irrigated out of GCA in the combined sample. Of which 54.2 percent irrigated areas were found in region 1 and 36.3 percent in region 2. Moreover, about 50.6 percent irrigated lands in the sample are served by naturally flow waterways in the combined sample region. Of which about 62 percent were found in region 1 and 38 percent in region 2 (Table 5.4).

On the other hand, about 49.4 percent land areas are served by modern irrigation equipments. It is interesting to note that, most of these modern irrigation equipments were found to be privately owned by individual farmers. Pumpsets, Borewells, and Tubewells are the main modern irrigation equipments found in the sample. No other irrigation systems like canal, sluicegate, etc. found in the sample during the study period. Thus, the total irrigated areas in the sample are partly irrigated by naturally flowing waterways and partly by modern irrigation equipments like Pumpsets, Tubewells and Borewells.

Table 5.4: Distribution of land in the sample

| Name of the Villages | Naturally flow waterways | | Irrigation equipments | | Total irrigated area | |
|---|---|---|---|---|---|---|
| | Area (ha) | % to total irrigated | Area (ha) | % to total irrigated | Area (ha) | % to GCA |
| Hasaobari | 20.8 | 49.8 | 21.0 | 50.2 | 41.8 | 54.9 |
| Simlaguri | 23.9 | 53.6 | 20.7 | 46.4 | 44.6 | 55.2 |
| Gopdapara | 22.6 | 67.7 | 10.8 | 32.3 | 33.4 | 53.4 |
| Gengraypara | 19.5 | 85.6 | 3.3 | 14.4 | 22.8 | 56.5 |
| Dologaon | 21.9 | 67.8 | 10.4 | 32.2 | 32.3 | 51.5 |
| **Region 1** | **108.7** | **62.0** | **66.2** | **37.8** | **174.9** | **54.2** |
| Bautipara | 12.7 | 42.1 | 17.5 | 57.9 | 30.2 | 41.7 |
| Landanguri | 14.4 | 50.2 | 14.3 | 49.8 | 28.7 | 28.0 |
| Puradia | 13.9 | 41.6 | 19.5 | 58.4 | 33.4 | 32.4 |
| Baoraguri | 9.8 | 23.9 | 31.2 | 76.1 | 41.0 | 41.5 |
| Batabari | 10.4 | 37.5 | 17.4 | 62.5 | 27.8 | 41.6 |
| **Region 2** | **61.2** | **38.0** | **99.8** | **62.0** | **161.0** | **36.3** |
| **Total Sample** | **169.9** | **50.6** | **166.0** | **49.4** | **335.9** | **43.9** |

Source: Author's Calculation from Field Survey Data, 2012

### 5.3 Utilization of Irrigation in the Sample: Source-Wise

In this section, an attempt has been made to examine the source-wise utilisation of available irrigation in the sample. According to the irrigation commission of India, there are four types (canals, tanks, wells and other sources) of irrigation sources. These sources of irrigation are further classified by their nature under three categories, viz, surface flow[1],

[1] The surface flow irrigation scheme is a diversion scheme of river water through distribution channels. That is, in surface flow irrigation, the natural flows of stream of rivers are diverted into a canal artificially constructed by placing a weir across the flow and distribute the water in the agricultural field.

surface lift [2]and ground water lift[3]. Generally, Assam has surfaced flow, surface lift and ground water lift irrigation facilities. However, the distributions of such irrigation are found to be unequal in the state. Very few rich and fortunate farmers are able to harvest the benefit of such costly irrigation systems in the state. In our field survey also found the presence of modern irrigation equipments like Pumpsets, Borewells, Tubewells, etc. in the sample villages. It is observed that a few farmers used such modern irrigation equipments in the sample, although the utilisation of such modern irrigation equipments is not so familiar among the sample farmers.

### 5.3.1 Area under Naturally Flow Waterway

Naturally flow waterway is one of the major sources of irrigation among the farmers in the sample. Farmers generally in the sample, lifted the water from streams and tributaries of rivers by constructing traditional *dong* with mud, bamboo or bushes. In the combined regions, for about 49.1 percent of sample households uses the naturally flow waterways as the major source of irrigation for paddy cultivation. It is further found that, about 76.3 percent sample households in region 1 depend on naturally flow waterways for paddy cultivation. The utilisation of naturally flow waterways was found to be more during winter season. Owning to abundant of groundwater level, the water in streams, tributaries of rivers, etc. dry away during summer and autumn season. As a result the dependent on naturally flow waterways decline in the sample region, especially during summer and autumn season. On the other hand, only 25.3 percent sample households in region 2 are fortunate enough to harvest the natural flow waterway for paddy cultivation. The reason

[2] The surface lift irrigation scheme is to lift water from surface water resources by means of electrical or diesel operated Pumpset and distributes the water to the agricultural fields. Generally, perennial river water is the main source of surface lift irrigation scheme.

[3] The ground water lift irrigation scheme is generally lifted from the ground below the surface by sinking tubewell for distributing the water to the fields for use in cultivation. Generally, there are two types of tube wells, i.e, deep tube well and shallow tube well. The division of tube well depend on the nature of ground water resource and dept of the tube well. In shallow tube well water may fluctuate and the depth of the tubewell should be 20 to 25 meters only. On the other hand, water level in deep tube well does not fluctuate but remain constant. Moreover, the depth of well is about 100 to 150 meters.

behind the low utilisation of naturally flow waterways in region 2 is due to lack of tributaries of rivers and streams. The only river falls near the sample region 2 is Pagladia tributaries. Generally, the water level of Pagladia tributaries depends on rainfall. If there is high rainfall in the region, the water level of Pagladia tributary is raised and vice-versa. Moreover, the water in Pagladia dries up during summer and autumn seasons. Hence, the utilisation of naturally flowing waterways is very less in region 2.

Accordingly, about 22.2 percent gross cropped areas are served by naturally flow waterways irrigation in the sample combined sample region (Table 5.5). Moreover, about 40.8 percent gross irrigated areas are irrigated by naturally flow waterways. The area under naturally flow waterways is more in region 1 as compared to region 2. On an average about 14.6 percent of gross cropped areas in region 1 are served by naturally flow waterways and only 8.0 percent in region 2.

Table 5.5: Area under naturally flow waterways in the sample

| Name of the Villages | HH with Naturally Flow Waterways Irrigation | | Area under Naturally Flow Waterways Irrigation | | |
|---|---|---|---|---|---|
| | No.of HH | % to total HH | Area (ha) | % of GIA | % of GCA |
| Hasaobari | 24 | 17.9 | 37.0 | 8.9 | 4.8 |
| Simlaguri | 26 | 19.4 | 39.9 | 9.6 | 5.2 |
| Gopdapara | 9 | 6.7 | 18.6 | 4.5 | 2.4 |
| Gengraypara | 20 | 14.9 | 30.7 | 7.4 | 4.0 |
| Dologaon | 31 | 23.1 | 49.8 | 12.0 | 6.5 |
| **Region 1** | **110** | **82.1** | **108.7** | **26.1** | **14.2** |
| Bautipara | 11 | 5.9 | 12.3 | 3.0 | 1.6 |
| Landanguri | 9 | 4.8 | 15.4 | 3.7 | 2.0 |
| Puradia | 12 | 6.5 | 16.2 | 3.9 | 2.1 |
| Baoraguri | 8 | 4.3 | 13.2 | 3.2 | 1.7 |
| Batabary | 7 | 3.8 | 12.0 | 2.9 | 1.6 |
| **Region 2** | **47** | **25.3** | **61.2** | **14.7** | **8.0** |
| **Total Sample** | **157** | **46.2** | **169.9** | **40.8** | **22.2** |

Source: Author's Calculation from Field Survey Data, 2012

Note: GIA & GCA denotes Gross Irrigated Area & Gross Cropped Area respectively

### 5.3.2 Area under Pumpsets Irrigation in the Sample

As stated in the previous chapter, the rainfall in the state is not equally distributed across seasons. Therefore, depending on rainfall for paddy cultivation is difficult during summer and autumn season in the state in general and particular in the sample regions. During these seasons, owing to absence of adequate rainfall, the perennial river water dries up. Thus, the ultimate solution to avoid the negative effect of uncertain rainfall is to use artificial water system. Usually, farmers in the sample region used Pumpset irrigation system to irrigate their paddy fields. In order to irrigate their paddy crop through Pumpset, farmers pump out water from surface flow and then connect water into the agricultural field. Thus, irrigation supply through Pumpsets is another source of irrigation in the sample especially during dry season. Along with Pumpset irrigation, farmers also used other irrigation systems such as Tubewells, Borewells, Dugwells, etc. during the summer and autumn seasons.

Table 5.6: Area under pumpset irrigation in the sample

| Name of the villages | HH with Pumpsets Irrigation | | Area under Pumpsets irrigation | | |
|---|---|---|---|---|---|
| | No.of HH | % to total HH | Area (ha) | % of GIA | % of GCA |
| Hasaobari | 10 | 7.5 | 9.6 | 2.3 | 1.3 |
| Simlaguri | 9 | 6.7 | 10.7 | 2.6 | 1.4 |
| Gopdapara | 6 | 4.5 | 8.3 | 2.0 | 1.1 |
| Gengraypara | 9 | 6.7 | 9.5 | 2.3 | 1.2 |
| Dologaon | 11 | 8.2 | 11.1 | 2.7 | 1.4 |
| **Region 1** | **45** | **33.6** | **49.2** | **11.8** | **6.4** |
| Bautipara | 12 | 6.5 | 7.7 | 1.9 | 1.0 |
| Landanguri | 16 | 8.4 | 11.1 | 2.7 | 1.4 |
| Puradia | 18 | 9.7 | 12.1 | 2.9 | 1.6 |
| Baoraguri | 17 | 9.1 | 12.2 | 2.9 | 1.6 |
| Batabary | 8 | 4.3 | 8.1 | 1.9 | 1.1 |
| **Region 2** | **52** | **38.0** | **51.1** | **12.3** | **6.7** |
| **Total Sample** | **97** | **35.8** | **131.3** | **31.5** | **17.1** |

Source: Author's Calculation from Field Survey Data, 2012

Utilisation of Pumpset irrigation system is a costly affair. Moreover, almost all the sample farmers are small and marginal farmers. As a result, the utilisation of Pumpset irrigation system in the sample is very less. In other words, only a few farmers could afford to use such costly irrigation system for paddy cultivation. Thus, it is found that, only few able farmers used Pumpset irrigation system in the combined sample. According to data presented in Table 5.6, out of total sample households, about 35.8 percent farmer households have Pumpset irrigation system in the combined sample regions. Out of which 33.6 percent are from region 1 and 38 percent are from region 2. Similarly, the areas under Pumpset irrigation system in the sample regions are also presented in Table 5.6. The area served by Pumpset irrigation was 17.1 percent out of the total gross cropped area in the combined sample. Similarly, the area under Pumpset irrigation was 31.5 percent out of total irrigated area in the combined sample regions. Thus, it is clear that, the sample farmers in both the regions utilize Pumpset irrigation system in paddy cultivation although the utilisation rate is less.

### 5.3.3 Area under Dugwells Irrigation System in the Sample

Irrigation through Dugwell irrigation system is another source of irrigation in the sample. According to field survey data, about 86.5 percent sample households possess Dugwells in the sample. Although, the number of Dugwell is large, usually most of these Dugwells are used for drinking or other domestic purposes. Only few farmers were found utilising Dugwell water for paddy crop cultivation. Thus, utilisation of irrigation through Dugwells was also found in the sample region although there are less number of users. The number of households who possess Dugwells for crop cultivation and areas under Dugwell irrigation system is presented in Table 5.7.

Only 9.1 percent sample households are found using Dugwell water for their paddy cultivation in the combined sample regions. Of these, 10.4 percent households are from region 1 and only 8.1 percent households are from region 2. Moreover, out of total gross cropped area only 2.6 hectares of land areas are covered by Dugwells irrigation system in the sample.

Table 5.7: Area under dugwell irrigation system in the sample

| Name of the Villages | HH with Dugwell Irrigation | | Area under Dugwell irrigation | | |
|---|---|---|---|---|---|
| | No.of HH | % to total HH | Area (ha) | % of GIA | % of GCA |
| Hasaobari | 2 | 1.5 | 2.3 | 0.6 | 0.3 |
| Simlaguri | 3 | 2.2 | 2.1 | 0.5 | 0.3 |
| Gopdapara | 3 | 2.2 | 0.8 | 0.2 | 0.1 |
| Gengraypara | 2 | 1.5 | 1.2 | 0.3 | 0.2 |
| Dologaon | 4 | 3.0 | 2.2 | 0.5 | 0.3 |
| **Region 1** | 14 | 10.4 | **8.7** | **2.1** | **1.1** |
| Bautipara | 2 | 1.1 | 2.1 | 0.5 | 0.3 |
| Landanguri | 4 | 2.2 | 2.1 | 0.5 | 0.3 |
| Puradia | 3 | 1.6 | 2.7 | 0.7 | 0.4 |
| Baoraguri | 4 | 2.2 | 2.0 | 0.5 | 0.3 |
| Batabary | 2 | 1.1 | 2.6 | 0.6 | 0.3 |
| **Region 2** | **15** | 8.1 | **11.5** | **2.8** | **1.5** |
| **Total Sample** | **29** | **9.1** | **20.2** | **4.9** | **2.6** |

Source: Author's Calculation from Field Survey Data, 2012

Of these, 1.1 percent are in region 1 and 1.5 percent are in region 2. Moreover, only 4.9 percent of gross irrigated areas are served by Dugwell irrigation system in the combined sample regions. Thus, it is found that, few farmers in the sample use Dugwell irrigation system for paddy cultivation in the sample although numbers of users are very less. Like Pumpset irrigation system, utilisation of Dugwell irrigation system is also costly. Hence, only few middle and high income farmers used the Dugwell irrigation system for paddy crop cultivation in the sample region are found during the study period.

### 5.3.4 Area under Tubewells Irrigation System in the Sample

Irrigation through Tubewell is another source of irrigation in the sample. Farmers in the sample use Tubewell irrigation system for paddy cultivation during the summer and autumn seasons. Generally, during the summer and autumn season, the groundwater level goes down. Owing to this, the streams, river water dries up. Moreover, even the water of Dugwells goes down and also dries up. Hence, utilisation of water through Dugwells, Borewells and naturally flowing waterways become difficult for the sample farmers.

Because of this, farmers use Tubewell irrigation system as an alternative source of irrigation for paddy cultivation in the sample especially during the summer and autumn seasons. Although farmers in the sample utilise Tubewell irrigation system, the number of users are very less.

Table 5.8: Area under tubewell irrigation system in the sample

| Name of the villages | HH with Tubewell Irrigation | | Area under Tubewell irrigation | | |
|---|---|---|---|---|---|
| | No.of HH | % to total HH | Area (ha) | % of GIA | % of GCA |
| Hasaobari | 3 | 2.2 | 3.0 | 0.7 | 0.4 |
| Simlaguri | 3 | 2.2 | 2.9 | 0.7 | 0.4 |
| Gopdapara | 2 | 1.5 | 2.1 | 0.5 | 0.3 |
| Gengraypara | 3 | 2.2 | 1.4 | 0.3 | 0.2 |
| Dologaon | 4 | 3.0 | 2.7 | 0.6 | 0.3 |
| **Region 1** | **15** | **11.2** | **12.1** | **2.9** | **1.6** |
| Bautipara | 4 | 2.2 | 2.7 | 0.6 | 0.3 |
| Landanguri | 3 | 1.6 | 2.7 | 0.7 | 0.4 |
| Puradia | 5 | 2.7 | 3.2 | 0.8 | 0.4 |
| Baoraguri | 6 | 3.2 | 3.2 | 0.8 | 0.4 |
| Batabary | 3 | 1.6 | 2.4 | 0.6 | 0.3 |
| **Region 2** | **21** | **11.3** | **14.2** | **3.4** | **1.9** |
| **Total Sample** | **36** | **11.3** | **26.2** | **6.3** | **3.4** |

Source: Author's Calculation from Field Survey Data, 2012

Data presented in Table 5.8 shows that, out of 320 sample households only 11.3 percent households use Tubewell irrigation system in the combined sample for paddy crop cultivation. Of these, 11.2 percent are from region 1 and 11.3 are from sample region 2. In addition, on an average about 3.4 percent area out of total gross cropped areas are served by Tubewell irrigation system in the combined sample villages. Out of which about 1.6 percent of land area in region 1 and 1.9 percent in region 2 are under Tubewell irrigation system. The data further show that, only 6.3 percent out of total irrigated areas are served by Tubewell irrigation system in the sample.

### 5.3.5 Area under Borewell Irrigation System in the Sample

Although it is one of the major source of irrigation only a few farmers were found using Borewell irrigation system in the sample during our field survey. Out of total sample households, only 20 households owned Borewell irrigation system, which is very less. The area under Borewell irrigation system also showed that, only 5.8 percent out of total irrigated areas are irrigated through Borewell irrigation system in the combined sample regions. The irrigated area through Borewell irrigation system was found more in region 2 as compared to region 1

Table 5.9: Area under borewell irrigation system in the sample

| Name of the Villages | HH with Borewells Irrigation | | Area under Borewells Irrigation | | |
|---|---|---|---|---|---|
| | No.of HH | % to total HH | Area (ha) | % of GIA | % of GCA |
| Hasaobari | 3 | 2.2 | 1.0 | 0.2 | 0.1 |
| Simlaguri | 2 | 1.5 | 1.9 | 0.4 | 0.2 |
| Gopdapara | 1 | 0.7 | 2.1 | 0.5 | 0.3 |
| Gengraypara | 2 | 1.5 | 1.4 | 0.3 | 0.2 |
| Dologaon | 3 | 2.2 | 2.7 | 0.6 | 0.3 |
| **Region 1** | **11** | **8.2** | **9.1** | **2.2** | **1.2** |
| Bautipara | 1 | 0.5 | 2.7 | 0.6 | 0.3 |
| Landanguri | 2 | 1.1 | 2.7 | 0.7 | 0.4 |
| Puradia | 3 | 1.6 | 3.2 | 0.8 | 0.4 |
| Baoraguri | 2 | 1.1 | 4.2 | 1.0 | 0.5 |
| Batabary | 1 | 0.5 | 2.4 | 0.6 | 0.3 |
| **Region 2** | **9** | **4.8** | **15.2** | **3.6** | **2.0** |
| **Total Sample** | **20** | **6.3** | **24.2** | **5.8** | **3.2** |

Source: Author's Calculation from Field Survey Data, 2012

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On an average about 3.6 percent area under paddy was irrigated through Borewell irrigation system in region 1 and only 2.2 percent area under paddy was irrigated through Borewell irrigation in region 2. Moreover, only 3.2 percent area under paddy crop out of gross cropped areas are irrigated through Borewell irrigation system in the combined sample regions. It shows that about 3.2 percent out of gross cropped area under paddy cultivation are served by Borewell irrigation system in region 2.

Lack of knowledge and poor economic condition are the main reason for less utilisation of Borewell. Generally, farmers in the sample are not familiar with the Borewell irrigation system. Besides, installation or utilisation of the Borewell irrigation system is a very costly affair like Tubewell and Dugwells irrigation system. It is required a good investment on it. Thus, the installation and utilisation of such costly irrigation system were difficult for sample farmers, especially for those farmers who are small and marginal. Generally, most of the marginal and small farmers are from low income group. Therefore, irrigating the paddy field with the help of the Borewell irrigation system was found to be low in the sample villages.

### 5.4 Utilisation of Irrigation in the Sample: Across Seasons

In the previous sections, we have discussed about the number of users and area under different irrigation systems in the sample region thoroughly. It is found that naturally flowing waterways served as the main source of irrigation in the sample. Besides, modern irrigation equipments such as like Pumpsets, Borewells, Tubewells, etc. have been used by sample farmers especially during summer and autumn season. Thus, in this section, an attempt has been made to examine the season-wise utilisation of irrigation potential in the sample region.

#### 5.4.1 Irrigation Utilisation in Paddy Cultivation: Winter Season

Winter or main kharif season is the main season for growing paddy in the state in general and in the sample region in particular. During the kharif season the region gets heavy rainfall. Owing to this, the streams and river tributaries, including cultivated areas become full of water specially, whenever there is heavy rainfall. This encourages farmers to grow varieties of paddy crops. Accordingly, farmers grow both modern and traditional paddy crops in the sample. The most prominent modern HYV paddy verities grown in the sample are *Lakhimi, Bahadur, Moniram, Ranjit, Mahsuri, Sonamukhi*, etc. On an average about 54.4 percent area out of the total gross cropped area in the sample are used for winter paddy (Sali rice) cultivation. The area under Sali rice was found more in region 1 with 79.3 percent of total GCA. At the same time, about 36.3 percent of gross cropped areas were utilized for Sali rice cultivation in sample region 2 (Table 5.10). On the other hand, 44.7 percent of gross cropped areas were used for Boro cultivation in the combined sample regions. Moreover, about 36.5 percent and area out of total gross cropped areas were utilized for Ahu Rice cultivation in the sample. Thus, it is found that, Sali rice is the dominant crop in the sample region covering the highest land area of gross cropped area.

Table 5.10: Area under paddy crop across seasons (Area in Ha)

| Regions | Sali rice | | Boro rice | | Ahu rice | |
|---|---|---|---|---|---|---|
| | Area | % to GCA | Area | % to GCA | Area | % to GCA |
| Region 1 | 255.3 | 79.3 | 130.2 | 40.4 | 109.9 | 34.1 |
| Region 2 | 161.1 | 36.3 | 211.9 | 47.8 | 170.0 | 38.3 |
| Total Sample | 416.3 | 54.4 | 342.1 | 44.7 | 331.2 | 36.5 |

Source: Field Survey Data, 2012

Rainfall during winter season rejuvenates the streams and river water and generates immense water in Aie and Makhra rivers. The water of these rivers is harnessed by means of collectively owned lifted irrigation system. Water is lifted usually by constructing small dams on the river. Into lift irrigation system, farmers laid out narrow canals or distributory channels and poured water into cultivated fields. Table 5.11 shows the paddy area under different sources of irrigation in the sample. It was found that 46.2 percent area under paddy is served by naturally flowing waterways during winter season in the combined sample villages. However, about 71.7 percent area under paddy was served by naturally flow waterways in region 1. On the other hand, about 27.6 percent areas under paddy cultivation were served by naturally flow waterways in region 2.

Table 5.11: Irrigated area by different irrigation sources during Winter season

| Name of the Villages | Irrigated area under different irrigation sources (Ha) | | | | | | % of irrigated area by different sources to GCA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Naturally flow waterways | Pumpsets | Dugwells | Borewells | Tubewells | Total area | Naturally flow waterways | Pumpsets | Dugwells | Borewells | Tubewells | Total area |
| Hasaobari | 56.1 | 2.3 | 1.2 | 0.4 | 1.0 | 61.1 | 7.3 | 0.3 | 0.2 | 0.1 | 0.1 | 8.0 |
| Simlaguri | 61.0 | 2.1 | 0.7 | 1.1 | 1.1 | 66.1 | 8.0 | 0.3 | 0.1 | 0.1 | 0.1 | 8.6 |
| Gopdapara | 45.0 | 1.4 | 1.1 | 1.0 | 0.6 | 49.1 | 5.9 | 0.2 | 0.1 | 0.1 | 0.1 | 6.4 |
| Gengraypara | 26.5 | 1.9 | 0.9 | 0.6 | 1.0 | 30.8 | 3.5 | 0.2 | 0.1 | 0.1 | 0.1 | 4.0 |
| Dologaon | 42.5 | 2.4 | 1.5 | **0.8** | 1.2 | 48.3 | 5.5 | 0.3 | 0.2 | 0.1 | 0.2 | 6.3 |
| **Region 1** | **231.1** | **10.1** | **5.3** | **3.9** | **4.9** | **255.3** | **30.2** | **1.3** | **0.7** | **0.5** | **0.6** | **33.3** |
| Bautipara | 24.2 | 1.2 | 1.6 | 1.7 | 1.6 | 30.2 | 3.2 | 0.2 | 0.2 | 0.2 | 0.2 | 3.9 |
| Landanguri | 22.2 | 1.3 | 2.6 | 2.2 | 0.4 | 28.7 | 2.9 | 0.2 | 0.3 | 0.3 | 0.0 | 3.7 |
| Puradia | 24.5 | 3.7 | 2.5 | 1.8 | 0.9 | 33.5 | 3.2 | 0.5 | 0.3 | 0.2 | 0.1 | 4.4 |
| Baoraguri | 30.8 | 3.9 | 2.5 | 1.9 | 2.0 | 41.0 | 4.0 | 0.5 | 0.3 | 0.2 | 0.3 | 5.4 |
| Batabary | 20.9 | 2.4 | 1.6 | 2.0 | 0.9 | 27.8 | 2.7 | 0.3 | 0.2 | 0.3 | 0.1 | 3.6 |
| **Region 2** | **122.6** | **12.5** | **10.7** | **9.5** | **16.4** | **161.1** | **16.0** | **1.6** | **1.4** | **1.2** | **2.1** | **21.0** |
| **Total Sample** | **353.7** | **22.6** | **16.1** | **13.4** | **21.3** | **416.4** | **46.2** | **2.9** | **2.1** | **1.8** | **2.8** | **54.4** |

Source: Author's Calculation from Field Survey Data, 2012

Besides naturally flowing waterways, ground water irrigation is another source of irrigation for paddy cultivation during winter season. Farmers in the sample harnessed ground water through privately owned Borewells, Tubewells, Pumpsets and Dugwells. Although, groundwater served another source of irrigation in the sample, the area under groundwater irrigation is very less. On an average, only 9.6 percent areas under paddy are covered by groundwater irrigation during winter season in the combined sample villages. The area under Borewells, Tubewells, Pumpsets and Dugwells are presented in Table 5.11. According to survey data, only 2.9 percent of the paddy areas out of the total GCA are served by Pumpsets irrigation in the combined sample regions. In addition, about 2.8 percent and 2.1 percent paddy areas out of the total CGA area are served by Tubewells and Dugwells respectively. Thus, it is found that naturally flow waterways served as the main source of irrigation for paddy cultivation in the sample especially during winter season.

### 5.4.2 Irrigation Utilisation in Paddy Cultivation: Summer Season

As stated above, farmers in both the sample regions heavily dependent on rainwater for paddy cultivation. But depending on rain water for paddy cultivation, especially during summer is hardly feasible in the state as whole and in the sample region in particular. As stated in chapter 2, the rainfall in Assam is not equally distributed across the season. Rainfall in the state is concentrated only on a few months (June-September) almost every year. Thus, depending on rain water for Boro rice cultivation in the sample is hardly feasible. Water in Aie and Makhra tributaries is perennial in nature, although the water level goes down during the summer and autumn seasons. Thus, few farmers in sample region 1 could harness the perennial water for summer paddy cultivation. But owing to less water or deep level of water, the utilisation rate of this perennial water through dam water is low. Only 20.5 percent paddy areas are served by naturally flow waterways in region 1 during summer season.

Table 5.12: Irrigated area by different irrigation sources during summer season

| Name of the Villages | Irrigated area under different irrigation sources (Ha) | | | | | | % of irrigated area by different sources to GCA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Naturally flow | Pumpsets | Dugwells | Borewells | Tubewells | Total area | Naturally flow | Pumpsets | Dugwells | Borewells | Tubewells | Total area |
| Hasaobari | 12.4 | 21.9 | 2.2 | 4.3 | 2.1 | 43.0 | 1.6 | 2.9 | 0.3 | 0.6 | 0.3 | 5.6 |
| Simlaguri | 13.2 | 24.9 | 3.0 | 5.9 | 3.3 | 50.3 | 1.7 | 3.2 | 0.4 | 0.8 | 0.4 | 6.6 |
| Gopdapara | 12.4 | 19.0 | 3.1 | 4.8 | 1.0 | 40.3 | 1.6 | 2.5 | 0.4 | 0.6 | 0.1 | 5.3 |
| Gengraypara | 15.0 | 21.9 | 2.6 | 5.4 | 1.8 | 46.6 | 2.0 | 2.9 | 0.3 | 0.7 | 0.2 | 6.1 |
| Dologaon | 13.1 | 22.7 | 3.7 | 4.2 | 1.5 | 45.3 | 1.7 | 3.0 | 0.5 | 0.6 | 0.2 | 5.9 |
| **Region 1** | **66.1** | **110.5** | **14.6** | **24.7** | **9.7** | **225.5** | **8.6** | **14.4** | **1.9** | **3.2** | **1.3** | **29.4** |
| Bautipara | 6.1 | 22.0 | 2.1 | 3.2 | 5.8 | 39.1 | 0.8 | 2.9 | 0.3 | 0.4 | 0.8 | 5.1 |
| Landanguri | 7.2 | 24.1 | 3.7 | 4.5 | 8.4 | 47.9 | 0.9 | 3.1 | 0.5 | 0.6 | 1.1 | 6.3 |
| Puradia | 8.0 | 21.0 | 4.0 | 4.7 | 8.1 | 45.7 | 1.0 | 2.7 | 0.5 | 0.6 | 1.1 | 6.0 |
| Baoraguri | 5.9 | 25.6 | 2.3 | 7.9 | 5.0 | 46.6 | 0.8 | 3.3 | 0.3 | 1.0 | 0.6 | 6.1 |
| Batabary | 4.1 | 16.5 | 2.1 | 6.1 | 3.9 | 32.6 | 0.5 | 2.1 | 0.3 | 0.8 | 0.5 | 4.3 |
| **Region 2** | **31.3** | **109.1** | **14.1** | **26.4** | **31.1** | **211.9** | **4.1** | **14.2** | **1.8** | **3.4** | **4.1** | **27.7** |
| **Total Sample** | **97.4** | **219.5** | **28.7** | **51.0** | **40.8** | **437.4** | **12.7** | **28.7** | **3.7** | **6.7** | **5.3** | **57.1** |

Source: Author's Calculation from Field Survey Data, 2012

Since region 2 is far from such perennial waterways, utilisation of naturally flow waterways for summer crop cultivation is comparatively lower as compared to region 1. Only about 10.7 percent paddy areas during the summer season are served by naturally flow waterways in region 2. Only few farmers, whose land are in lower lying areas could use naturally flow waterways for summer crop cultivation in region 2.

Thus, farmers in the combined sample region had to depend mostly on pumpsets, Borewells, Tubewells and Dugwells irrigation of irrigated paddy lands in summer season. Farmers in both the regions derived the largest proportion of water from pumpsets (28.7 percent) during summer season followed by naturally flow waterways (14.8 percent), Borewells (5.6 percent) and Tubewells (4.3 percent). However**,** the overall utilisation of irrigation through pumpsets irrigation in paddy cultivation was found more (34.3 percent) in region 1 as compared to region 2 (Table 5.12). In addition, the paddy area served by Tubewells irrigation was 5.2 percent of the total gross cropped area in region 2 which is higher than in region 2 (3 percent).

### 5.4.3 Irrigation Utilisation in Paddy Cultivation: Autumn Season

Pre-kharif rice, popularly known as Ahu rice in Assam and particularly in sample region is cultivated during autumn season. The sowing season starts from the month of February and harvesting season starts from June. The Ahu rice is cultivated in two ways in the sample, i.e. directly sowing (seeded) and by transplantation. In the case of direct sowing, rice is directly seeded without any transplantation. And directly seeded Ahu rice is cultivated mostly in dry land, i.e. under rainfed condition in the sample. On the other hand, farmers also cultivate Ahu rice by transplanting system. For the transplantation system of Ahu rice cultivation proper irrigation facility is required. Thus, most of the farmers use pumpsets, Tubewells, Borewells and Dugwells irrigation in the sample for the transplantation system of Ahu rice cultivation. Moreover, the sample farmers grow both traditional and HYVs Ahu rice. Traditional Ahu varieties like *Koimurali* and *Kasalath* are still popular among the farmers in the sample because of their shorter duration and water stress tolerance.

Table 5.13: Irrigated area by different irrigation sources during Autumn season

| Name of the Villages | Irrigated area under different irrigation sources (Ha) | | | | | | % of irrigated area by different sources to GCA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Naturally flow | Pumpsets | Dugwells | Borewells | Tubewells | Total area | Naturally flow waterways | Pumpsets | Dugwells | Borewells | Tubewells | Total area |
| Hasaobari | 8.4 | 16.9 | 1.2 | 3.3 | 1.1 | 31.0 | 1.1 | 2.2 | 0.2 | 0.4 | 0.1 | 4.1 |
| Simlaguri | 9.2 | 18.9 | 2.0 | 3.9 | 2.3 | 36.3 | 1.2 | 2.5 | 0.3 | 0.5 | 0.3 | 4.7 |
| Gopdapara | 8.4 | 17.0 | 2.1 | 2.8 | 1.1 | 31.4 | 1.1 | 2.2 | 0.3 | 0.4 | 0.1 | 4.1 |
| Gengraypara | 10.0 | 15.9 | 1.6 | 3.4 | 0.8 | 31.6 | 1.3 | 2.1 | 0.2 | 0.4 | 0.1 | 4.1 |
| Dologaon | 8.1 | 16.7 | 2.7 | 2.2 | 1.0 | 30.8 | 1.1 | 2.2 | 0.4 | 0.3 | 0.1 | 4.0 |
| **Region 1** | **44.1** | **85.5** | **9.6** | **15.7** | **6.3** | **161.2** | **5.8** | **11.2** | **1.3** | **2.0** | **0.8** | **21.0** |
| Bautipara | 4.1 | 17.0 | 2.8 | 3.6 | 3.8 | 31.2 | 0.5 | 2.2 | 0.4 | 0.5 | 0.5 | 4.1 |
| Landanguri | 4.2 | 19.1 | 4.7 | 4.6 | 5.5 | 38.1 | 0.5 | 2.5 | 0.6 | 0.6 | 0.7 | 5.0 |
| Puradia | 5.0 | 19.0 | 3.8 | 4.0 | 6.4 | 38.1 | 0.7 | 2.5 | 0.5 | 0.5 | 0.8 | 5.0 |
| Baoraguri | 3.9 | 16.6 | 2.5 | 3.1 | 5.8 | 31.8 | 0.5 | 2.2 | 0.3 | 0.4 | 0.8 | 4.1 |
| Batabary | 3.1 | 17.5 | 3.7 | 2.2 | 4.5 | 30.9 | 0.4 | 2.3 | 0.5 | 0.3 | 0.6 | 4.0 |
| **Region 2** | **20.3** | **89.1** | **17.4** | **17.4** | **25.9** | **170.0** | **2.6** | **11.6** | **2.3** | **2.3** | **3.4** | **22.2** |
| **Total Sample** | **64.4** | **174.5** | **27.0** | **33.0** | **32.3** | **331.2** | **8.4** | **22.8** | **3.5** | **4.3** | **4.2** | **43.2** |

Source: Author's calculations from field survey data

However, the traditional rice is cultivated in both systems (directly seeded and transplantation) in the sample. Apart from traditional Ahu rice, modern HYV varieties of Ahu rice are cultivated in the sample villages. Since the cultivation of modern Ahu varieties absorbs higher water as compared to traditional Ahu rice, the creation of sufficient irrigation is very much important. Thus, farmers in the sample villages were found utilising Pumpsets, Borewells, Dugwells and Tubewells irrigation especially in Ahu rice cultivation. Table 5.13 shows the distribution of source-wise irrigated area under Ahu rice in the sample. Out of total GCA about 331.2 hectares of land are brought under Ahu rice cultivation in the sample. Of these 77.4 hectares (17.5 percent) are under directly seeded (rainfed) Ahu rice. Owing to the uncertain rainfall during the autumn season, farmers in the sample villages used alternative irrigation facility. Thus, utilisation of water through Pumpsets, Borewells, Dugwells and Tubewells were also found in the sample. On an average about 39.4 percent area under Ahu rice was served by Pumpsets irrigation in the combined sample villages. Moreover, the HYV varieties of Ahu rice required proper system. The utilisation of Pumpsets water was found more in region1 (26.5 percent) as compared to region 2 (20.1 percent). Moreover, about 7.4 percent area under Ahu rice was served by Borewells irrigation in the sample. The study also found that, about 5.5 percent and 5 percent of area under Ahu rice were served by Tubewells and Dugwells irrigation respectively.

Thus, from the above discussion, it is found that the potential irrigation created for paddy cultivation in the sample region was found very low. The systematic irrigation system was found to be absent in the sample regions. Thus, the rainwater and naturally flow waterways served as main sources of irrigation for paddy cultivation in the combined sample villages. In addition to this, utilisation of available groundwater irrigation through Pumpsets, Tubewells, Borewells, Dugwells were also found in the sample. The presence of Pumpsets, Tubewells, Borewells and Dugwells irrigation system was found in the sample, although the rate of utilisation of these irrigation systems was comparatively very low. Out of total gross cropped area only 43.9 percent is irrigated. Of which 50.6 percent are irrigated through naturally flow waterways and 49.4 percent area are irrigated through Pumpsets, Borewells, Dugwells, and Tubewells irrigation systems. Thus, it is found that, although there is huge potential of ground water irrigation development in the state in general and particular in sample region, the scenario of irrigation is not up to the mark. The utilisation of modern irrigation equipments is still not much familiar among the sample farmers. Although the utilisation of modern irrigation equipments was found not much familiar yet the utilisation of modern irrigation equipments such as Tubewells, Borewells, Pumpsets were found in the sample although small in number. However, the utilisation of sparking irrigation, drip water, sluicegate, canal irrigation system, etc. was found non existence in the sample. Moreover, the tributaries of Aie and Makhra have immense prospect for irrigation development in the sample region. In spite of the enormous panorama of irrigation development in the region, the farmers in the sample deprived for irrigation especially during summer and autumn season. Thus, in the next section an attempt has been made to examine the factors responsible for the low creation and utilisation of irrigation potential in the sample.

### 5.5 Reasons behind Low Irrigation Development in the Sample

In this section an attempt has been made to examine the factors responsible for low irrigation development in the sample. Accordingly, we have collected the information through a structured questionnaire from sample households in both the regions. The responses of the sample farmers are presented in Table 5.14.

#### (a) Low Irrigation Potential Created

The absence of irrigation potential created in the sample is the major reason for low utilisation of irrigation in the sample. In the previous section, we have seen that very few farmers use the modern irrigation equipments such as Tubewells, Pumpsets, Borewells, etc. The creation of irrigation through the canal, drip water, sluicegate, sprinkle water etc. were found totally absent although there is high possibility of a canal and ground water irrigation in the sample. The creation of such irrigation is expensive in nature. Moreover, it is found that the sample region is dominated by small and marginal farmers. Thus, the creation of such expensive irrigation is not feasible for sample farmers. According to data collected from samples, only 6.3 percent sample households have access to Borewell irrigation system in the sample. Moreover, it is found that about 22.8 percent sample households have Dugwells but most of these are used for domestic consumption only. The utilisation of irrigation through Dugwell irrigation system for agricultural activities was found very less in the sample. Nevertheless, the utilisation of Pumpsets irrigation system was found more as compared to other irrigation systems among the sample. On an average about 36.6 percent sample households used Pumpset irrigation system in the sample. Although the farmers are familiar with Pumpset irrigation system yet utilisation rate is very low. According to our data, about 95.5 percent sample households said that, lack of creation of irrigation facility is the main reason for low utilisation of irrigation in the sample. They said that, although there is an enormous possibility of canal irrigation system through the tributaries of Aie and Makhra tributaries, the creation of such irrigation facility has not been done yet. They further alleged that, creation of such irrigation could facilitate the farmers a lot.

Table 5.14: Reasons behind poor irrigation development in the sample

| Name of the villages | Lack of creation | Responses of household to total sample households (%) | | | | |
|---|---|---|---|---|---|---|
| | | Low income | Lack of knowledge | Flood problem | Problem of electricity | Institutional problem |
| Hasaobari | 95.1 | 80.0 | 70.0 | 63.3 | 73.3 | 89.8 |
| Simlaguri | 97.7 | 71.0 | 54.8 | 51.6 | 64.5 | 79.1 |
| Gopdapara | 91.3 | 66.7 | 58.3 | 50.0 | 58.3 | 82.7 |
| Gengraypara | 97.0 | 72.7 | 68.2 | 59.1 | 72.7 | 78.8 |
| Dologaon | 94.1 | 76.9 | 61.5 | 51.3 | 66.7 | 85.8 |
| **Region1** | **95.0** | **74.6** | **62.7** | **55.2** | **67.9** | **83.2** |
| Bautipara | 92.9 | 78.6 | 42.9 | 46.4 | 67.9 | 77.9 |
| Langdanguri | 97.5 | 83.3 | 78.6 | 73.8 | 73.8 | 86.0 |
| Puradia | 98.2 | 77.3 | 70.5 | 61.4 | 70.5 | 82.3 |
| Baoraguri | 94.9 | 70.5 | 63.6 | 54.5 | 72.7 | 79.8 |
| Batabary | 95.9 | 82.1 | 67.9 | 57.1 | 75.0 | 83.7 |
| **Region 2** | **95.9** | **78.0** | **66.1** | **59.7** | **72.0** | **81.9** |
| **Total Sample** | **95.5** | **76.6** | **64.7** | **57.8** | **70.3** | **82.6** |

Source: Field Survey Data, 2012

**(b) Lack of Knowledge on Utilisation**

Lack of awareness is another factor for low utilisation of irrigation in the sample. Owing to their poor knowledge regarding the modern irrigation equipments, they still practised old traditional method of irrigation system in the cultivation of crops. They believe in traditional sources of irrigation like check dam, earthen dams, dong, etc. Moreover, due to illiteracy of modern irrigation equipments, many farmers preferred traditional way of crop cultivation. Hence, most of them depend on the water channelling system. While questioning about the knowledge of the modern irrigation equipments, about 64.7 percent sample households said that they are not aware about such irrigation system. They further said that, the utilisation of modern irrigation equipments will not boost the agricultural productivity without the proper utilisation of modern farm inputs such as HYV seeds, application of fertilizer which required a huge investment. Thus, they do not like to use such equipments which are not user friendly. Hence, many of them prefer to confine in traditional method of irrigation system.

**(c) Poor Economic Condition of the Sample Farmers**

Financial constraint is another major problem faced by most of the farmers in general and by sample farmer in particular. In the previous chapter (chapter 3) it is seen that about 68.8 percent (405 workers) out of total sample workers are directly dependent on agriculture for their livelihood. Most of them earned income from agricultural activities which is very low. Owing to their low income, they are not able to raise personal irrigation system. Only few able farmers whose annual average income is a little better off could raise personal irrigation system for paddy cultivation. Therefore, few sample farmers have installed Borewells, purchased Pumpset machine, use Dugwells, Tubewells to increase the irrigation system in paddy production. Thus, about 76.6 percent sample households in the sample said that low income of the family is another major factor responsible for poor creation of irrigation facilities and low utilisation of irrigation.

**(d) Electricity Shortage**

Many farmers said that the acute power shortage in the region is a serious bottleneck in the utilisation of existing irrigation facilities. Due to electricity shortage, many farmers are not able to use pumpsets irrigation facilities. Energising the pumpsets-diesel is the only option for farmers to use Pumpset irrigation system. Thus, many farmers are using pumpsets with diesel. The uses of Pumpset by diesel considerably push up the running costs and hence imposing a heavy burden on the farmer's exchequer. Hence, operating pumpset with diesel is very costly. As a result, many farmers are not able to use the Pumpset machine for irrigation paddy crops in the sample. On an average, about 70.3 percent sample farmers said that shortage of electricity in the region is another major problem of using the existing irrigation system.

**(e) Problem of Floods**

Occurrence of frequent flood due to excess rainwater during kharif season in every year is another important problem faced by farmers in the sample. Flood is a major natural disaster regularly causing damage of various standing crops, population, animals, road and transportation and public utilities. Generally, most of the farmers in the sample construct earthen dams for water channelling from river/streams in paddy field. They directly supply water from a stream or river to paddy field through constructing a small dam. Most of the time, these dams are washed away by excess rainwater and floods. Moreover, sometimes, the excess rainwater and flood water damage the existing irrigation system. About 57.8 percent farmers in combined sample said that excess rainwater and flood water is another factor for poor irrigation development in the sample. Of these, about 59.5 percent farmer households of region 2 and 62.7 percent households in region 1 said that, along with other factors, erratic rainfall and frequent floods may be responsible for the low irrigation development in the sample.

**(f) Institutional Problem**

Lack of proper attention towards the irrigation development in the region by irrigation department is another problem for poor irrigation scenario in the sample. An Irrigation department in the state is not taking any step for implementation of minor and major irrigation schemes due to geographical location. The existing naturally flow waterways, rivers, water and streams water which are the main sources of irrigation in the sample are under-utilised owing to lack of proper channel**.** In addition, naturally flow waterways, river water, stream water is not perennial. It dried up during the summer and autumn season. Hence, there is a water shortage in the sample. Thus, for preservation of available water for summer and autumn, construction of irrigation storage facilities is very needful. Thus, it is the responsibility of concerned department to construct some sort of storage facilities in the sample. This will help farmers in the full utilisation of existing irrigation facilities. Nevertheless, it is found that the concerned departments (agricultural department and irrigation ministry) are not taking any initiative to install such technology yet in the sample region. The irrigation systems developed so far by the farmers themselves in a region are almost all river diversion schemes without any provision for supplying irrigation water during the non monsoon season. Almost all farmers in the sample use naturally flow waterways by river diversion schemes. On average, about 82.2 percent farmers in the sample said that the static approach adopted by the planners and policy makers in formulating irrigation policy of the state is a major contributing factor in the bulging gap over irrigation distribution in the sample region.

## 5.6 Findings and Summary

This chapter discussed the availability and utilisation of irrigation facilities for paddy in the sample regions in Assam. From the above discussions, some important points can be drawn as given below:

- Rainfall and naturally flowing waterways are the main sources of irrigation for paddy cultivation in the sample region.

- Out of total gross cropped area, only 43.9 percent area under paddy cultivation are irrigated in the combined sample regions. Of these, about 49.4 percent is irrigated through irrigation equipments such as Pumpsets, Borewells, Tubewells, etc. On the other hand, about 50.6 percent areas under paddy cultivation were irrigated by naturally flowing waterways.
- The field study also found the existence of modern irrigation equipments such as Pumpsets, Borewells, and Tubewells in the sample. But utilisation of the systematic irrigation system such as canal irrigation, drip irrigation, sprinkle irrigation, etc. were found nil during the study period.
- The source-wise availability of irrigation in the sample shows that about 22.2 percent of the area under paddy cultivation were served by naturally flowing waterways. On the other hand, 13.1 percent areas are served by pumpsets irrigation system followed by Tubewells (3.4 %,) Borewells (3.2 %) irrigation systems.
- Season-wise irrigation utilisation showed that sali rice (winter rice), which is cultivated during June-July and harvested in November-December, is mostly cultivated through naturally flowing waterways and rainwater. About 46.2 percent of areas under sali rice was cultivated by naturally flowing waterways during the study period.
- Out of total gross cropped area, about 28.7 percent of Boro rice areas were cultivated through Pumpset irrigation system in the combined sample. Since, ground water level goes down and water of river, tributaries and stream dries up during the summer season, very few farmers could use naturally flowing waterways for Boro rice cultivation.
- Ahu rice which is cultivated in autumn season is mostly cultivated with the help of modern irrigation equipments rather than rainfall and naturally flowing waterways. During this season, most of the farmers used pumpset irrigation to cultivate Ahu rice in the sample. On an average, about 39.4 percent areas under Ahu rice cultivation was irrigated by pumpset irrigation system in the sample during the study period. Other than Pumpset irrigation, farmers also used Dugwells,

Borewells, Tubewells and partly by naturally flow waterways for Ahu rice cultivation.

- There are various reasons for poor irrigation development and poor utilisation of created irrigation in the sample. Factors such as poor economic conditions of farmers, lack of awareness about modern irrigation equipments, frequent floods and water logging during rainy season, electricity shortage, institutional problems are some of the main factors responsible for poor irrigation development in the sample region.

Based on these findings, now we proceed to the next chapter to examine the impact of irrigation on the yield variations of paddy crop across three seasons in an agricultural year in the sample with the help of primary field survey data**.**

Table 5.11: Irrigated area by different irrigation sources during Winter season

| Name of the Villages | Irrigated area under different irrigation sources (Ha) | | | | | | % of irrigated area by different sources to GCA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Naturally flow waterways | Pumpsets | Dugwells | Borewells | Tubewells | Total area | Naturally flow waterways | Pumpsets | Dugwells | Borewells | Tubewells | Total area |
| Hasaobari | 56.1 | 2.3 | 1.2 | 0.4 | 1.0 | 61.1 | 7.3 | 0.3 | 0.2 | 0.1 | 0.1 | 8.0 |
| Simlaguri | 61.0 | 2.1 | 0.7 | 1.1 | 1.1 | 66.1 | 8.0 | 0.3 | 0.1 | 0.1 | 0.1 | 8.6 |
| Gopdapara | 45.0 | 1.4 | 1.1 | 1.0 | 0.6 | 49.1 | 5.9 | 0.2 | 0.1 | 0.1 | 0.1 | 6.4 |
| Gengraypara | 26.5 | 1.9 | 0.9 | 0.6 | 1.0 | 30.8 | 3.5 | 0.2 | 0.1 | 0.1 | 0.1 | 4.0 |
| Dologaon | 42.5 | 2.4 | 1.5 | **0.8** | 1.2 | 48.3 | 5.5 | 0.3 | 0.2 | 0.1 | 0.2 | 6.3 |
| **Region 1** | **231.1** | **10.1** | **5.3** | **3.9** | **4.9** | **255.3** | **30.2** | **1.3** | **0.7** | **0.5** | **0.6** | **33.3** |
| Bautipara | 24.2 | 1.2 | 1.6 | 1.7 | 1.6 | 30.2 | 3.2 | 0.2 | 0.2 | 0.2 | 0.2 | 3.9 |
| Landanguri | 22.2 | 1.3 | 2.6 | 2.2 | 0.4 | 28.7 | 2.9 | 0.2 | 0.3 | 0.3 | 0.0 | 3.7 |
| Puradia | 24.5 | 3.7 | 2.5 | 1.8 | 0.9 | 33.5 | 3.2 | 0.5 | 0.3 | 0.2 | 0.1 | 4.4 |
| Baoraguri | 30.8 | 3.9 | 2.5 | 1.9 | 2.0 | 41.0 | 4.0 | 0.5 | 0.3 | 0.2 | 0.3 | 5.4 |
| Batabary | 20.9 | 2.4 | 1.6 | 2.0 | 0.9 | 27.8 | 2.7 | 0.3 | 0.2 | 0.3 | 0.1 | 3.6 |
| **Region 2** | **122.6** | **12.5** | **10.7** | **9.5** | **16.4** | **161.1** | **16.0** | **1.6** | **1.4** | **1.2** | **2.1** | **21.0** |
| **Total Sample** | **353.7** | **22.6** | **16.1** | **13.4** | **21.3** | **416.4** | **46.2** | **2.9** | **2.1** | **1.8** | **2.8** | **54.4** |

Source: Author's Calculation from Field Survey Data, 2012

Table 5.12: Irrigated area by different irrigation sources during summer season

| Name of the Villages | Irrigated area under different irrigation sources (Ha) | | | | | | % of irrigated area by different sources to GCA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Naturally flow | Pumpsets | Dugwells | Borewells | Tubewells | Total area | Naturally flow | Pumpsets | Dugwells | Borewells | Tubewells | Total area |
| Hasaobari | 12.4 | 21.9 | 2.2 | 4.3 | 2.1 | 43.0 | 1.6 | 2.9 | 0.3 | 0.6 | 0.3 | 5.6 |
| Simlaguri | 13.2 | 24.9 | 3.0 | 5.9 | 3.3 | 50.3 | 1.7 | 3.2 | 0.4 | 0.8 | 0.4 | 6.6 |
| Gopdapara | 12.4 | 19.0 | 3.1 | 4.8 | 1.0 | 40.3 | 1.6 | 2.5 | 0.4 | 0.6 | 0.1 | 5.3 |
| Gengraypara | 15.0 | 21.9 | 2.6 | 5.4 | 1.8 | 46.6 | 2.0 | 2.9 | 0.3 | 0.7 | 0.2 | 6.1 |
| Dologaon | 13.1 | 22.7 | 3.7 | 4.2 | 1.5 | 45.3 | 1.7 | 3.0 | 0.5 | 0.6 | 0.2 | 5.9 |
| **Region 1** | **66.1** | **110.5** | **14.6** | **24.7** | **9.7** | **225.5** | **8.6** | **14.4** | **1.9** | **3.2** | **1.3** | **29.4** |
| Bautipara | 6.1 | 22.0 | 2.1 | 3.2 | 5.8 | 39.1 | 0.8 | 2.9 | 0.3 | 0.4 | 0.8 | 5.1 |
| Landanguri | 7.2 | 24.1 | 3.7 | 4.5 | 8.4 | 47.9 | 0.9 | 3.1 | 0.5 | 0.6 | 1.1 | 6.3 |
| Puradia | 8.0 | 21.0 | 4.0 | 4.7 | 8.1 | 45.7 | 1.0 | 2.7 | 0.5 | 0.6 | 1.1 | 6.0 |
| Baoraguri | 5.9 | 25.6 | 2.3 | 7.9 | 5.0 | 46.6 | 0.8 | 3.3 | 0.3 | 1.0 | 0.6 | 6.1 |
| Batabary | 4.1 | 16.5 | 2.1 | 6.1 | 3.9 | 32.6 | 0.5 | 2.1 | 0.3 | 0.8 | 0.5 | 4.3 |
| **Region 2** | **31.3** | **109.1** | **14.1** | **26.4** | **31.1** | **211.9** | **4.1** | **14.2** | **1.8** | **3.4** | **4.1** | **27.7** |
| **Total Sample** | **97.4** | **219.5** | **28.7** | **51.0** | **40.8** | **437.4** | **12.7** | **28.7** | **3.7** | **6.7** | **5.3** | **57.1** |

Source: Author's Calculation from Field Survey Data, 2012

Table 5.13: Irrigated area by different irrigation sources during Autumn season

| Name of the Villages | Irrigated area under different irrigation sources (Ha) | | | | | | % of irrigated area by different sources to GCA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Naturally flow | Pumpsets | Dugwells | Borewells | Tubewells | Total area | Naturally flow waterways | Pumpsets | Dugwells | Borewells | Tubewells | Total area |
| Hasaobari | 8.4 | 16.9 | 1.2 | 3.3 | 1.1 | 31.0 | 1.1 | 2.2 | 0.2 | 0.4 | 0.1 | 4.1 |
| Simlaguri | 9.2 | 18.9 | 2.0 | 3.9 | 2.3 | 36.3 | 1.2 | 2.5 | 0.3 | 0.5 | 0.3 | 4.7 |
| Gopdapara | 8.4 | 17.0 | 2.1 | 2.8 | 1.1 | 31.4 | 1.1 | 2.2 | 0.3 | 0.4 | 0.1 | 4.1 |
| Gengraypara | 10.0 | 15.9 | 1.6 | 3.4 | 0.8 | 31.6 | 1.3 | 2.1 | 0.2 | 0.4 | 0.1 | 4.1 |
| Dologaon | 8.1 | 16.7 | 2.7 | 2.2 | 1.0 | 30.8 | 1.1 | 2.2 | 0.4 | 0.3 | 0.1 | 4.0 |
| **Region 1** | **44.1** | **85.5** | **9.6** | **15.7** | **6.3** | **161.2** | **5.8** | **11.2** | **1.3** | **2.0** | **0.8** | **21.0** |
| Bautipara | 4.1 | 17.0 | 2.8 | 3.6 | 3.8 | 31.2 | 0.5 | 2.2 | 0.4 | 0.5 | 0.5 | 4.1 |
| Landanguri | 4.2 | 19.1 | 4.7 | 4.6 | 5.5 | 38.1 | 0.5 | 2.5 | 0.6 | 0.6 | 0.7 | 5.0 |
| Puradia | 5.0 | 19.0 | 3.8 | 4.0 | 6.4 | 38.1 | 0.7 | 2.5 | 0.5 | 0.5 | 0.8 | 5.0 |
| Baoraguri | 3.9 | 16.6 | 2.5 | 3.1 | 5.8 | 31.8 | 0.5 | 2.2 | 0.3 | 0.4 | 0.8 | 4.1 |
| Batabary | 3.1 | 17.5 | 3.7 | 2.2 | 4.5 | 30.9 | 0.4 | 2.3 | 0.5 | 0.3 | 0.6 | 4.0 |
| **Region 2** | **20.3** | **89.1** | **17.4** | **17.4** | **25.9** | **170.0** | **2.6** | **11.6** | **2.3** | **2.3** | **3.4** | **22.2** |
| **Total Sample** | **64.4** | **174.5** | **27.0** | **33.0** | **32.3** | **331.2** | **8.4** | **22.8** | **3.5** | **4.3** | **4.2** | **43.2** |

Source: Author's calculations from field survey data

# Chapter 6

# Irrigation and Yield Variation of Paddy in Sample

## 6.1 Introduction

The previous chapter discussed the availability and utilisation of different irrigation systems in the sample regions. The study found that irrigation facility, which is one of the most important inputs for paddy cultivation, is low in the sample. It is widely argued in many studies that the yield of rice per unit of land is always higher in irrigated areas as compared to rainfed areas. This is evident from the studies like Rosegrant and Perez1 (1997), Ringler et al. (2000), Hussain and Hanjra (2004), Lipton et al. (2005) etc. The direct benefit of irrigation in paddy cultivation is that it increases the farm productivity by diversification of cropping patterns and crop technologies. Moreover, effective use of irrigation increases cropping intensity, uses of HYV seeds, consumption of chemical fertilizer and hence increases the productivity of paddy. Thus, access to irrigation water is widely recognized to be one of the major underlying factors for the significant increase in productivity. There exists a large number of reports and research papers, which examine the impact of irrigation on paddy cultivation. Some of such studies include Sharma (1992), Vaidyanathan and Rajagopal (1992;1994), Vaidyanathan (1994), Bezbaruah (1994), Dhawan (1998), Goswami and Chatterjee (2003), Shukla et al. (2003), Bastiaanssen and Zwart (2004), Goswami and Chatterjee (2006), Bosumatari and Goyari (2008), Mythili (2008), Dutta (2011), and Upadhyay (2012). They observed the higher yield of paddy in irrigated land as compared to un-irrigated land (also see the review section 1.2 in chapter 1 for details).

Moreover, it is widely argued by various studies that irrigation tends to increase the responsiveness of agricultural output to various inputs and therefore it is likely to be positively correlated with input use intensity (Jin et al., 2012). Although the annual cost of cultivation of irrigated agriculture is higher as compared to rainfed agriculture, nevertheless, it yields a net positive return due to intensive input use. Moreover, irrigation increases the use of all other inputs.

Beside irrigation, there are several other factors which affect the productivity and production of any crop. Technology, quality of soil, quality of seeds, fertilizer consumption, pesticides, implements, credit are the some of the factors which affect agricultural production and productivity. These factors are interdependent and interlinked with one another. Their timely availability in desired quantity is very much important to increase the production and productivity. Thus, the yield of rice per unit of land is influenced by several factors. For example, systematic use of fertilizers, HYV seeds, irrigation, pesticide, etc. may increase the paddy yield per hectare. Paddy yield also tends to be high in a region having fertile soil and suitable agro-climatic conditions. However, excessive rainfall and consequences of heavy floods, droughts, pest attacks, etc. tend to make the rice yield low in a region. Technique of cultivation, modern or traditional, can also determine the level of yield per unit of land. Studies like Dayal (1965), Sagar (1980); Lahiri and Roy (1985) elaborate the negative impact of flood and drought on paddy productivity. Kainth and Mehra (1985) examine varying effects of droughts, attack of insects and pests, fertilizers, demographic factors, market system, pesticides, climatic conditions technological and institutional factors on the productivity of paddy. Studies of such as Mahajan et al.(1986), Shukla et al.(2003), Haque (1985), Hazzell and Ramasamy (1986), Ramasamy et al. (1992), and Shah (1997), Rosegrant (1994), Tikkiwal and Tikkiwal (1998), Siju and Kombairaju (2001), Singh and Kalra (2002), Goswami and Chatterjee (2003, 2006), Zhou et al. (2010) and Singha (2011) etc. emphasized the importance of utilisation of fertilizer, irrigation, HYV seeds, etc. on the yield of paddy.

Therefore, an attempt has been made to examine the impact of irrigation, fertilizer consumption and HYV seeds on the productivity of paddy with the help of primary field survey data. Accordingly, the present chapter is divided into following sections. Section 6.2 examines the impact of irrigation on productivity of rice across seasons and sources. In section 6.3, the impact of fertilizer on the yield of rice is examined and section 6.4 examines the impact of HYVs on productivity of rice. Section 6.5 gives the description of model to examine econometrically the impact of irrigation, fertilizer uses and adoption of HYV seeds on yield of rice in the sample. Section 6.6 gives discussions on the estimated results. The last section 6.7 gives the main findings and summary of the chapter.

Although several factors are responsible for the yield variation of rice in Assam in general and the sample region in particular, non-availability of data for all variables restricts us from examining each and every factor. Therefore, we examine only some selected variables which are responsible for yield variation of rice per unit of land in the sample across seasons.

### 6.2 Irrigation and Yield of Paddy

In this section, an attempt has been made to examine the impact of irrigation on yield of paddy in the sample. For this, we have classified yield of paddy into high productivity, medium productivity, low medium productivity, low productivity and very low productivity. [1]Yield more than 2500 kg/ha is termed as high productivity. On the other hand, yield less than 2500 kg/ha but more than 1500 kg/ha is under medium and low medium productivity. Moreover, kg/ha less than 1500 but more than 1000 kg/ha is low productivity and below 1000 kg/ha is termed as very low productivity. As stated in chapter 3, paddy is cultivated in three different seasons in the sample. Accordingly, the utilisation of irrigation in these three seasons is not the same. During the dry season, the adoption of modern irrigation equipments is more as compared to winter season owing to available rainwater and naturally flow waterways. Owing to this, the extent of irrigation utilisation and productivity level of paddy crop is also differs. Thus, irrigation utilisation and productivity across seasons and across different sources are discussed in this section. Accordingly, the average yield of paddy both in irrigated and un-irrigated land is presented in Table 6.1.

The yield of rice in irrigated land was found to be more as compared to un-irrigated[2] land in the sample. The yield of rice in irrigated land was 1772.9 kg per hectare during the

[1] The classification of firm productivity was made on the basis of Dutta (2011) classification in his book "Irrigation Development in Assam"

[2] In present study, the un-irrigated land includes those lands that do not have access to any means of irrigation except rainwater.

study period. The irrigated land in the sample can produce only medium level of productivity as per classification. On the other hand, the yield of rice in un-irrigated land in the sample was only 976.2 kg/ha which is very less. According to yield classification, below 1000 kg per hectare of productivity is under very productivity. Thus, the rice yield in un-irrigated land in the sample is termed as very low productivity.

Table 6.1: Average yield of rice in irrigated and un-irrigated land (yield in kg/ha)

| Name of the Villages | Irrigated Rice | | | Un-irrigated Rice | | | Yield Gap |
|---|---|---|---|---|---|---|---|
| | Area (Ha) | in % | Yield | Area (Ha) | in % | Yield | |
| Hasoabari | 41.8 | 54.9 | 1823.2 | 34.4 | 45.1 | 996.5 | 826.7 |
| Simlaguri | 44.6 | 55.2 | 1783.3 | 36.3 | 44.8 | 1024.7 | 758.6 |
| Gengraypara | 33.4 | 53.4 | 1812.9 | 29.1 | 46.6 | 887.9 | 925.1 |
| Gopdapara | 22.8 | 56.5 | 1906.6 | 17.5 | 43.5 | 1044.4 | 862.1 |
| Dologaon | 32.3 | 51.5 | 1774.3 | 30.4 | 48.5 | 989.4 | 784.9 |
| **Region 1** | **174.9** | **54.2** | **1820.1** | **147.6** | **45.8** | **988.6** | **831.5** |
| Bautipara | 30.2 | 41.7 | 1795.6 | 42.1 | 58.3 | 929.4 | 866.2 |
| Landanguri | 28.7 | 28.0 | 1811.2 | 73.9 | 72.0 | 1058.6 | 752.6 |
| Puradia | 33.4 | 32.4 | 1684.3 | 69.8 | 67.6 | 868.4 | 815.9 |
| Baoraguri | 41.0 | 41.5 | 1830.4 | 57.7 | 58.5 | 976.7 | 853.7 |
| Batabary | 27.8 | 41.6 | 1506.7 | 38.9 | 58.4 | 986.1 | 520.6 |
| **Region 2** | **161.0** | **36.3** | **1725.6** | **282.3** | **63.7** | **963.8** | **761.8** |
| **Total Sample** | **335.9** | **43.9** | **1772.9** | **430.0** | **56.1** | **976.2** | **796.7** |

Source: Field Survey Data, 2012 $\chi 2 = 24.61$ d.f.= 3

Note: (a) In present study, the un-irrigated land includes those lands that do not have access to any means of irrigation except rainwater

(b) Yield gap of rice between irrigated and unirrigated was calculated by deducting yield of un-irrigated land to irrigated land

Moreover, it was also found that the rice productivity is more in irrigated land in all the sample villages as compared to un-irrigated land. On an average, the productivity of rice in sample region 1 was 1820.1 kg/ha in irrigated land and 1725.6 kg/ha in region 2. This shows higher productivity of rice in irrigated land in both the regions. The yield gap of irrigated and un-irrigated land was 797.7 kg/ha in the combined sample region. The $\chi2$ value has been computed to study the association of productivity in relation to irrigation, which is presented in Table 6.1. The calculated value of $\chi2$ is highly significant at 5% level of significance. This shows that the irrigation has direct and significant positive impact on productivity of paddy. This indicates that systematic use of irrigation system may increase the productivity of paddy in the sample.

### 6.3 Irrigation Utilization and Rice Productivity: Across Seasons

As mentioned earlier, we have three main rice growing seasons in the sample. These seasons are autumn season, winter season and summer season. The winter rice also known as Sali rice in Assam is grown from June - July and harvested in November- December. Winter rice is raised preferably in low-lying areas that remain flooded mainly during the rainy season. However, Sali rice is actually the leading rice crop, accounting for a major portion of the total area of the sample. Autumn rice known as Ahu in Assam is also cultivated in the sample. Generally, the Ahu rice is grown in the months of February-April and is harvested in June-July month in the sample region. Most of the Ahu rice varieties are of short duration varieties ranging from 90 to 110 days. In addition, the sample farmers also grow summer rice. Summer rice is so called as Rabi rice in the state. It is also known as Boro rice in Assam. The sowing time of summer rice is from November to February and harvesting time is from March to June. Boro rice is raised on a small scale. Thus, almost all the farmers do cultivate rice in all the three seasons. The high temperature and heavy rainfall during the monsoon rainy season is more suitable for paddy cultivation during winter season. Owing to its suitable weather condition and rainfall pattern, most of the farmers cultivate Sali rice in the sample. Thus, Sali rice cultivation is more popular than other two in the sample, although rice is grown in all three seasons.

Owing to the seasonal variation of rice cultivation, the uses of irrigation also vary across seasons. As a result, the productivity of standing crops varies across seasons. Therefore, in this section a brief analysis of productivity of rice across seasons and across different sources of irrigation is discussed with the help of field survey data.

### 6.3.1 Irrigation and Rice Productivity: Winter Season

Out of total GCA in the sample, about 416.3 hectares (54.3 percent) land areas were used for winter or Sali rice cultivation. The cultivation of rice during winter season is mostly dependent on rainfall and naturally flow waterways. Apart from rain water and naturally flowing water, the utilisation of modern irrigation equipments was also found in the sample. The rice cultivation in winter season is a gamble of monsoon. Owing to erratic weather condition, (i.e. shortage of rain or heavy rain lead to heavy flood) farmers are compelled to use modern irrigation equipments in the sample. Accordingly, the yield of rice in different irrigation system during winter season (Sali rice) is presented in Table 6.2. According to the data, cultivation of Sali rice in irrigated area produce higher yield as compared to un-irrigated Sali rice in the sample during the study period.

Table 6.2: Rice yield in irrigated and un-irrigated land in winter season

| Name of the Villages | Yield of rice in kg/ha | | |
|---|---|---|---|
| | Yield in Irrigated | Yield in Un-irrigated | Yield Gap |
| Hasoabari | 1622.4 | 996.5 | 626.0 |
| Simlaguri | 1674.1 | 1024.7 | 649.4 |
| Gengraypara | 1643.3 | 1123.9 | 519.5 |
| Gopdapara | 1587.5 | 1014.4 | 573.1 |
| Dologaon | 1659.1 | 989.4 | 669.7 |
| **Region 1** | **1637.3** | **1029.8** | 607.5 |
| Bautipara | 1741.1 | 1029.4 | 711.7 |
| Landanguri | 1645.2 | 978.6 | 666.6 |
| Puradia | 1697.4 | 968.4 | 729.1 |
| Baoraguri | 1675.4 | 997.7 | 677.7 |
| Batabary | 1692.3 | 986.1 | 706.2 |
| **Region 2** | **1690.3** | **992.0** | 698.3 |
| **Total Sample** | **1663.8** | **1010.9** | 652.9 |

Source: Same as in Table 6.1

The productivity of irrigated land was 1663.8 kg/hectare during the study period. On the other hand, in the same year, the productivity of un-irrigated land was only 1020.9 kg per hectare.

This implies that, farmers produce a medium low of productivity with irrigation facilities and low productivity without irrigation facilities in the sample. Thus, to increase paddy yield per hectare of land, assured irrigation is required in the sample.

Moreover, it is also seen that the average rice productivity in winter was 1637.3 kg/ha in irrigated land and 1029.8 kg/ha in un-irrigated land area. Similarly, the productivity of winter rice was found to be more in irrigated land in region 2. The average productivity of rice in irrigated land was 1690.3 kg/ha and 992.0 kg/ha in un-irrigated land in region 2.

As stated above, there are different types of irrigation system in the sample. Most commonly used irrigation sources in the sample are naturally flowing waterways, Pumpset, Tubewell, Borewell and Dugwell. The productivity of rice kg per hectare of different irrigation system is presented in Table 6.3. According to data presented in the Table, it is observed that the cultivation of rice by using Tubewell irrigation produces more as compared to other types of irrigation system. The productivity of winter rice through Tubewell irrigation system was about 1764.5 kg per hectare. On the other hand, the productivity of winter rice cultivation by rainwater was only 1012.2 kg per hectare during the study period. Moreover, the productivity of winter cultivation through naturally flow waterways was accounted about 1474.9 kg per hectare during the same period. Thus, cultivation of winter rice through natural flow of water had higher productivity as compared to productivity of rainfed winter rice.

Table 6.3: Irrigation utilisation and productivity of rice in winter season (yield kg/ha)

| Name of the Villages | Rainfall | Naturally flow waterways | Irrigation equipments | | | |
|---|---|---|---|---|---|---|
| | | | Pumpsets | Tubewells | Borewells | Dugwells |
| Hasoabari | 923.2 | 1423.2 | 1523.2 | 1821.6 | 1621.0 | 1723.2 |
| Simlaguri | 1083.3 | 1383.3 | 1783.3 | 1765.7 | 1754.8 | 1683.3 |
| Gengraypara | 1012.9 | 1412.9 | 1612.9 | 1801.6 | 1676.3 | 1712.9 |
| Gopdapara | 998.6 | 1506.6 | 1506.6 | 1608.2 | 1709.6 | 1606.6 |
| Dologaon | 1074.3 | 1474.3 | 1574.3 | 1791.7 | 1780.8 | 1674.3 |
| **Region 1** | **1018.5** | **1440.1** | **1600.1** | **1757.8** | **1708.5** | **1680.1** |
| Bautipara | 1015.6 | 1515.6 | 1915.6 | 1876.3 | 1782.3 | 1615.6 |
| Landanguri | 931.2 | 1411.2 | 1711.2 | 1682.8 | 1709.7 | 1711.2 |
| Puradia | 1084.3 | 1684.3 | 1684.3 | 1754.7 | 1679.6 | 1684.3 |
| Baoraguri | 891.4 | 1530.4 | 1830.4 | 1687.9 | 1698.0 | 1630.4 |
| Batabary | 1106.7 | 1406.7 | 1706.7 | 1854.1 | 1787.4 | 1706.7 |
| **Region 2** | **1005.8** | **1509.6** | **1769.6** | **1771.2** | **1731.4** | **1669.6** |
| **Total Sample** | **1012.2** | **1474.9** | **1684.9** | **1764.5** | **1720.0** | **1674.9** |

Source: Field Survey Data, 2012

In addition, the productivity of winter rice under Tubewell, Dugwell, Borewell, Pumpset irrigation system were found more as compared to naturally flow waterways and rainfed in the combined sample regions. On an average, the total productivity of winter rice under Tubewell, Dugwell, Borewell and Pumpsets was 1757.8 kg/ha, 1680.1 kg/ha, 1708.5 kg/ha and 1600.1kg /ha respectively in region 1. Likewise, the total productivity of winter rice under Tubewell, Dugwell, Borewell and Pumpsets was found higher than naturally flow waterways and rainwater in region 2.

No doubt, winter rice can be cultivated with the help of rain water during the winter season but the productivity of winter rice cultivated by rain water produce less as compared to other sources of irrigation. This might be due to the erratic nature of rainfall. Generally, rainfall is not equally distributed. Sometimes, rainfall comes prematurely or late. Due to which farmers are not willing to use modern farm inputs. Over dependent on rainfall and natural flow waterways for rice cultivation during winter is very risky. Thus, it is found that reducing over dependency on such irrigation by creating of appropriate irrigation system may increase the productivity of winter rice in the sample. Moreover, the appropriate use of created irrigation may help in boosting the productivity of winter rice in the region.

### 6.3.2 Irrigation Utilization and Rice Productivity: Summer Season

As stated in chapter 4, summer rice occupies the second largest rice area in the sample. Out of the total rice area in sample, about 16.5 percent of land is used for the cultivation of summer rice. Summer paddy (Boro rice) cultivation is not so popular among the sample farmers due to water scarcity. Generally, the summer season is a dry season. There is less rainfall, owing to which the water level of streams and river tributaries also goes down. Therefore, cultivating with rain water and naturally flow waterways become difficult. Thus a reliable water sources are necessary to cultivate summer rice in the sample. On the other hand, farmers in the sample are not able to afford the costly irrigation equipments. Thus, it was found that only few farmers took up summer rice cultivation during the study period.

The productivity of summer rice of both in irrigated land and un-irrigated land is presented in Table 6.4. The productivity of summer rice in irrigated land was 1497.9 kg per hectare in region 1 and 1460.5 kg per hectare in region 2. On an average, the productivity of summer rice was 1479.2 kg/ha in the combined sample during the study period. On the other hand, the productivity of summer in un-irrigated land was 1076.4 kg per hectare in the combined sample. It is found that the productivity of summer rice is higher in the irrigated land than un-irrigated land in the sample. Thus, the creation of more irrigation facilities and appropriate use of irrigation may increase the productivity of summer rice further. The productivity of summer rice according to different sources of irrigation is presented in Table 6.5. According to data presented in the Table, it is found that farmers in the sample use different irrigation sources such as Pumpset, Dugwell, Borewell and Tubewell in the cultivation of summer rice. It was also found that, some farmers also use naturally flow waterways for summer rice cultivation especially in low-lying areas. Among all, Pumpset and Tubewell were found more effective source of irrigation.

Table 6.4: Rice yield in irrigated and un-irrigated land in summer season

| Name of the Villages | Yield of rice in kg/ha | | Yield Gap |
|---|---|---|---|
| | Irrigated land | Un-irrigated land | |
| Hasoabari | 1467.2 | 1016.5 | 450.8 |
| Simlaguri | 1492.1 | 1124.7 | 367.4 |
| Gengraypara | 1455.1 | 1233.9 | 221.3 |
| Gopdapara | 1477.1 | 1024.4 | 452.7 |
| Dologaon | 1507.7 | 968.4 | 539.3 |
| **Region 1** | **1479.9** | **1073.6** | **406.3** |
| Bautipara | 1490.1 | 1029.4 | 460.7 |
| Landanguri | 1391.4 | 1218.6 | 172.8 |
| Puradia | 1498.6 | 1108.4 | 390.3 |
| Baoraguri | 1431.8 | 1053.7 | 378.2 |
| Batabary | 1490.3 | 986.1 | 504.2 |
| **Region 2** | **1460.5** | **1079.2** | **381.2** |
| **Total Sample** | **1470.2** | **1076.4** | **393.8** |

Source: Same as in Table 6.2

Accordingly, the productivity of summer paddy was the highest under Pumpset irrigation system followed by Tubewell, Borewell and Dugwell. On an average, the productivity of summer rice under Pumpset irrigation was about 1572 kg/per hectare followed by 1541.5 kg per hectare under Tubewell irrigation in the combined sample. Moreover, the productivity of summer rice under Borewell irrigation was 1484kg/ha and 1474.9 kg/ha for Dugwell irrigation system. On the other hand, the productivity of summer rice under naturally flow waterways was found only 1278.6 kg/per hectare which was very low as compared to other sources of irrigation. The region-wise summer rice productivity under different irrigation system also showed that the productivity of summer rice in both the sample region is higher under Pumpset and Tubewell irrigation system as compared to natural flow waterways. This implies that the assured irrigation system has a positive impact on the yield of summer rice in the sample. Thus, creation of proper and assured irrigation is very much important for summer paddy cultivation in the sample.

Table 6.5: Irrigation utilisation and yield of rice in summer season (yield in kg/ha)

| Name of the Villages | Naturally flow waterways | Irrigation equipments | | | |
|---|---|---|---|---|---|
| | | Pumpsets | Tubewells | Borewells | Dugwells |
| Hasoabari | 1309.2 | 1543.2 | 1632.6 | 1421.0 | 1430.2 |
| Simlaguri | 1221.3 | 1638.3 | 1535.7 | 1556.8 | 1508.3 |
| Gengraypara | 1312.9 | 1541.9 | 1554.6 | 1423.3 | 1442.9 |
| Gopdapara | 1306.6 | 1554.6 | 1587.2 | 1449.6 | 1487.6 |
| Dologaon | 1207.3 | 1603.3 | 1591.7 | 1570.8 | 1565.3 |
| **Region 1** | **1271.5** | **1576.3** | **1580.4** | **1484.3** | **1486.9** |
| Bautipara | 1356.6 | 1515.6 | 1506.3 | 1526.3 | 1545.6 |
| Landanguri | 1205.2 | 1432.2 | 1418.8 | 1469.7 | 1431.2 |
| Puradia | 1248.3 | 1653.3 | 1554.7 | 1539.6 | 1497.3 |
| Baoraguri | 1367.4 | 1580.4 | 1447.9 | 1400.2 | 1363.4 |
| Batabary | 1250.7 | 1656.7 | 1585.1 | 1482.4 | 1476.7 |
| **Region 2** | **1285.6** | **1567.6** | **1502.6** | **1483.6** | **1462.8** |
| **Total Sample** | **1278.6** | **1572.0** | **1541.5** | **1484.0** | **1474.9** |

Source: Field Survey Data, 2012

### 6.3.3 Irrigation Utilisation and Productivity: Autumn Season

Farmers in the sample also cultivate rice in autumn season, though it occupies very meager land areas. Out of total land area under autumn rice cultivation only 33.4 percent of land area is irrigated, remaining 66.2 percent land areas are un-irrigated (Field survey data 2012). This indicates that many farmers in the sample are dependent on either rainfall or the natural flow of waterways for autumn crop cultivation. Generally, farmers in the sample cultivate rice in two different ways, i.e. the wet Ahu rice (transplanted) and dry (direct sowing) rice. The directly sowing Ahu rice requires less irrigation as compared to transplanted Ahu rice. It was observed that the productivity of transplanted autumn rice was higher than direct sowing autumn rice. The average productivity of irrigated rice (transplanted) and un-irrigated (direct sowing) rice is presented in Table 6.6. The productivity of transplanted Ahu rice was observed to be higher in both the sample region.  The average productivity of transplanted

Ahu rice was 1501.8 hectares in region 1 and 1482.1 kg hectare in region 2. On an average, the productivity of transplanted Ahu rice was 1491.9 kg hectare in the combined sample. On the other hand, the productivity of direct sowing Ahu rice was 10072.6 kg/ha in region 1 and 1036 kg/ha in region 2. Thus, it was found that the productivity of Ahu rice can be increased by using proper irrigation system in the sample.

Table 6.6: Rice yield in irrigated and un-irrigated land in Autumn season

| Name of the Villages | Yield of rice in kg/ha | | Yield Gap |
|---|---|---|---|
| | Irrigated (transplanted) | un-irrigated (direct sowing) | |
| Hasoabari | 1482.0 | 1012.5 | 469.6 |
| Simlaguri | 1487.3 | 1124.7 | 362.6 |
| Gengraypara | 1516.7 | 1233.9 | 282.9 |
| Gopdapara | 1489.9 | 1004.4 | 485.5 |
| Dologaon | 1532.9 | 987.4 | 545.5 |
| **Region 1** | **1501.8** | **1072.6** | **429.2** |
| Bautipara | 1441.5 | 996.4 | 445.1 |
| Landanguri | 1461.8 | 1005.6 | 456.2 |
| Puradia | 1492.8 | 1068.4 | 424.5 |
| Baoraguri | 1495.2 | 953.7 | 541.5 |
| Batabary | 1518.9 | 1156.1 | 362.8 |
| **Region 2** | **1482.1** | **1036.0** | **446.0** |
| **Total Sample** | **1491.9** | **1054.3** | **437.6** |

Source: Same as in Table 6.4

As stated above autumn rice is cultivated in both dry land and wetland. The major sources of irrigation during the autumn season in the sample are naturally flowing waterways, Pumpset, Tubewell, Borewell and Dugwell. The productivity of autumn rice differs across various irrigation types. The productivity of autumn rice in the sample region is presented in Table 6.7. The productivity of autumn rice under Tubewell irrigation was found to be higher followed by Pumpset irrigation and Borewell irrigation in the sample. On an average, the productivity of autumn rice under Tubewell irrigation was 1562 kg per hectare in region1 and 1556.4 kg per hectare is region 2. Besides, the productivity of autumn rice under Pumpset irrigation was 1547.5 kg per hectare in the combined sample. On the other hand, the productivity of autumn rice with naturally flow waterways was only 11.53.1 kg per hectares in the combined sample regions. Thus, creation of proper irrigation for autumn rice cultivation is very important to increase the productivity.

Table 6.7: Irrigation and yield of rice in autunm season (yield kg/ha)

| Name of the Villages | Naturally flow waterways | Irrigation equipments | | | |
|---|---|---|---|---|---|
| | | Pumpsets | Tubewells | Borewells | Dugwells |
| Hasoabari | 1223.2 | 1630.2 | 1601.6 | 1532.0 | 1323.2 |
| Simlaguri | 1183.3 | 1508.3 | 1525.7 | 1435.8 | 1483.3 |
| Gengraypara | 1231.9 | 1539.9 | 1431.6 | 1567.3 | 1312.9 |
| Gopdapara | 1206.6 | 1467.6 | 1598.2 | 1370.6 | 1406.6 |
| Dologaon | 1174.3 | 1508.3 | 1652.7 | 1554.8 | 1674.3 |
| **Region 1** | **1203.9** | **1530.9** | **1562.0** | **1492.1** | **1440.1** |
| Bautipara | 1125.6 | 1505.6 | 1608.3 | 1458.3 | 1309.6 |
| Landanguri | 1041.2 | 1609.2 | 1587.8 | 1559.7 | 1411.2 |
| Puradia | 1134.3 | 1534.3 | 1643.7 | 1367.6 | 1584.3 |
| Baoraguri | 1203.4 | 1654.4 | 1407.9 | 1479.8 | 1430.4 |
| Batabary | 1006.7 | 1516.7 | 1534.1 | 1458.4 | 1678.7 |
| **Region 2** | **1102.2** | **1564.0** | **1556.4** | **1464.8** | **1482.8** |
| **Total Sample** | **1153.1** | **1547.5** | **1559.2** | **1478.4** | **1461.5** |

Source: Field Survey Data, 2012

From above discussion, it is found that, cultivation of rice with modern irrigation equipments has more productivity as compared to rainfed and naturally flow waterways. Variation on productivity of rice is also observed in the field depending on the types of irrigation. The performance of the privately owned Pumpset and Tubewell has been superior to that rainwater and naturally flow waterways. Thus, privately owned irrigation systems are more efficient than other means of irrigation and enabling farmers to produce higher. Adequate creation of irrigation and effective use of irrigation potential will help farmers to increase productivity in the sample.

### 6.4 Irrigation and Consumption of Fertilizer

Fertilizer is one of the most essential inputs to increase agricultural production. Being the key input, fertilizer increases the productivity by providing essential nutrients to the plants that soil cannot supply in adequate and appropriate amount. However, inadequate and imbalanced supply of required nutrients may reduce the productive capacity of land, which may result in low productivity. Sometimes even very fertile land becomes less fertile due to continuous cultivation on the same land for a long time which leads to further depletion of most deficient nutrients in the soil. Thus, use of chemical fertilizers in appropriate doses plays a crucial role in increasing the productivity of paddy in any region. There are several studies in the literature which explains the impact of fertilizer and other factors on yield of rice. Studies of Mahajan and Sharma (1981), Desai (1984), Haque (1985), Sinha and Schulpen, (1992), Tikkiwal and Tikkiwal (1998), Kumar and Rosegrant (1994), Siju and Kombairaju (2001), Singh and Kalra (2002), Goswami and Chatterjee (2003, 2006), Zhou et al. (2010), Bosumatari and Goyari (2010) and Singha (2011) have observed that fertilizer, HYV seeds, pesticides, systematic irrigation, marketing, storage, and transportation facilities, prices, agro-climatic factors, socio-economic condition etc. affect the yield of rice.(see details in chapter 1 review section)

However, there are several factors which further determined the rate of fertilizer application by farmers. This is supported by various previous studies. Christina (1978) examined the factors that affect the utilisation of chemical fertilizer by using regression analysis on field based data collected from 36 rice growing villages from South and South East Asia. Differences in the physical environment accounted to be the major factors that affect the fertilizer consumption across regions. The study found that availability of credit and price of the fertilizer are unresponsive to the fertilizer consumption. On the other hand, reliable irrigation system and adoption of high yielding varieties were found to be major factors that affect the utilisation of fertilizer in the sample. According to Balla (1979) Indian farmers are progressive and prompt in the adoption of modern technology, but unfortunately they are often a constraint by lack of credit for their investment in modern technology such as irrigation, high yielding varieties. The lack of systematic irrigation, high yielding varieties, etc. hinders the utilisation affect the adoption of fertilizer. Nagraj (1983) also found that irrigation has a dominant influence on the adoption of chemical fertilizer by farmers. According to him, irrigation is the main factor which affects the fertilizer consumption by farmers, although there are various other factors which affect the adoption of fertilizer. They further observed that factors like High yielding varieties, intensive crop, etc. also a positive effect on a farms fertilizer consumption. Studies of Rao and Siroli (1986), observed that areas with equip and proper irrigation, drainage facility, and free from natural hazard use more chemical fertilizer in West Godavari district of Andhra Pradesh. It is further observed that areas like frequent flood and drought, the utilisation of fertilizer considerably become risky. Many farmers do not like to adopt fertilizer in such area. According to the adoption of fertilizer in such area was found to be negligible. Ramaswamy et al. (1986) observed that the use of fertilizer increased in rice cultivation considerably with proper irrigation, farm size and the adequate extension of education, credit to enhance fertilizer use. They further observed that increasing irrigation system, credit, extension of education might increase the consumption of fertilizer. Waithaka (2007) examine the factors affecting the use of fertilizers and manure by smallholders in Western Kenya. According to them, availability of irrigation, environment, farm size, education of farmers affects the fertilizer consumption among the farmers. Kumar and Matsuoka (2009) used a regression model to examine the influence of socio-economic factors of the improved maize adopters on the decision to adopt fertilizers in the Chitwan district of Nepal. The estimated regression result showed that family size, irrigation availability, credit use and farm size have positive influence on use of fertilizer in maize production in the sample. Zhou et al. (2010) analysed the factors influencing the farmers' decisions on fertilizer use and the implications for water quality in Northern China using farm level data. To examine the determinants of fertilizer use intensity across farm households and factors influencing the overuse of nitrogen regression model were used. The estimated results showed that many subjective factors affect the farmer's decision on the utilisation of fertilizer significantly. They further observed that the availability of irrigation, gains in crop yield and expectation of higher earnings are correlated with fertilizer use intensity positively in the sample. On the other hand, farm size, manure application, soil fertility and the distance to fertilizer markets are negatively correlated with fertilizer consumption during the study period. Thus, it is found that, irrigation along with other factors affect the utilisation of fertilizer of farmers. Therefore, in this section an attempt has been made to examine the impact of fertilizer consumption on yield of rice in the sample with the help of field survey data.

### 6.4.1 Utilisation of Fertilizer in Sample

In sample region, farmers use both chemical and organic manure in rice cultivation. Thus, the fertilizer consumption is classified under chemical and organic manure in the present study. Accordingly, the utilisation of both chemical fertilizer and organic manure in the sample is presented in Table 6.8. Out of total households, 199 (62.2 %) farmers apply chemical fertilizer in the sample of which 88 households in region 1 and 111 in region 2. Besides, about 22.2 percent sample households use organic manure in rice cultivation in the combined sample region. Moreover, it is found that about 18.1 percent households in the combined sample region use both chemical and organic manure in rice cultivation. On the other hand, only 15.6 percent sample households in the sample are not using fertilizer in rice cultivation. This shows that about 85 percent sample households in the combined sample region use either chemical fertilizer or organic manure in paddy cultivation during the study period.

Table 6.8: Utilisation of fertiliser in sample

| Name of the Villages | No. of HH | | | HH without fertiliser | % of HH to total sample | | | Without fertiliser |
|---|---|---|---|---|---|---|---|---|
| | Chemical | Organic | Both | | Chemical | Organic | both | |
| Hasaobari | 14 | 8 | 5.0 | 8.0 | 4.4 | 2.5 | 1.6 | 2.5 |
| Simlaguri | 17 | 7 | 4.0 | 7.0 | 5.3 | 2.2 | 1.3 | 2.2 |
| Gopdapara | 8 | 4 | 2.0 | 0.0 | 2.5 | 1.3 | 0.6 | 0.0 |
| Gengraypara | 20 | 1 | 6.0 | 1.0 | 6.3 | 0.3 | 1.9 | 0.3 |
| Dologaon | 29 | 6 | 7.0 | 4.0 | 9.1 | 1.9 | 2.2 | 1.3 |
| **Region 1** | **88** | **26** | **24.0** | **20.0** | **27.5** | **8.1** | **7.5** | **6.3** |
| Bautipara | 17 | 9 | 4.0 | 2.0 | 5.3 | 2.8 | 1.3 | 0.6 |
| Landanguri | 24 | 11 | 7.0 | 7.0 | 7.5 | 3.4 | 2.2 | 2.2 |
| Puradia | 25 | 10 | 9.0 | 9.0 | 7.8 | 3.1 | 2.8 | 2.8 |
| Baoraguri | 30 | 7 | 8.0 | 7.0 | 9.4 | 2.2 | 2.5 | 2.2 |
| Batabary | 15 | 8 | 6.0 | 5.0 | 4.7 | 2.5 | 1.9 | 1.6 |
| **Region 2** | **111** | **45** | **34.0** | **30.0** | **34.7** | **14.1** | **10.6** | **9.4** |
| **Total Sample** | **199.0** | **71.0** | **58.0** | **50.0** | **62.2** | **22.2** | **18.1** | **15.6** |

Source: Same as in Table 6.2

As stated above, farmers in the sample region uses both chemical and organic manure in rice cultivation. Although farmers use organic manure in rice cultivation, they generally do not maintain any record of organic manure utilisation. As a result, the present study could present only chemical fertilizer utilisation data. The utilisation of chemical fertilizer kg per hectare in different rice growing seasons is presented in Table 6.9. According to field survey data, the utilisation of fertilizer kg/ha is higher in summer rice cultivation as compared to winter and autumn rice. On an average, the utilisation of fertilizer was 9.3 kg per hectare in summer rice cultivation. The utilisation of fertilizer in summer rice cultivation was 8.9 kg per hectare in region 1 and 9.8 kg per hectare in region 2. Farmers in the sample use less fertilizer during winter rice cultivation due to overflow of rainwater and flood. Accordingly, the utilisation of fertilizer account only 5 kg /hectare in winter rice cultivation in the sample during study period.

Table 6.9: Consumption of chemical fertiliser (in kg/ha)

| Villages | Winter rice | Summer rice | Autumn Rice |
|---|---|---|---|
| Hasaobari | 6.4 | 7.6 | 6.7 |
| Simlaguri | 5.6 | 8.9 | 4.3 |
| Gopdapara | 3.7 | 6.1 | 5.5 |
| Gengraypara | 4.7 | 10.0 | 6.0 |
| Dologaon | 4.9 | 11.8 | 5.0 |
| **Region 1** | **5.1** | **8.9** | **5.5** |
| Bautipara | 4.9 | 10.0 | 8.0 |
| Landanguri | 5.8 | 8.9 | 6.9 |
| Puradia | 4.8 | 10.1 | 7.9 |
| Baoraguri | 3.7 | 9.7 | 8.8 |
| Batabary | 5.7 | 10.3 | 9.9 |
| **Region 2** | **5.0** | **9.8** | **8.3** |
| **Total Sample** | **5.0** | **9.3** | **6.9** |

Source: Field Survey Data, 2012

### 6.4.2 Impact of Irrigation on Fertilizer Consumption

The use of fertilizer in rice cultivation under different irrigation system is presented in Table 6.10. The utilisation of chemical fertilizer required assured irrigation facility. Thus, availability of irrigation system determined the fertilizer utilisation rate. It is found that none of the farmers have utilized chemical fertilizer in rainfed rice in the combined sample region. Farmers were found using fertilizer under naturally flow waterways irrigation, Pumpset irrigation, Tubewell irrigation, Borewell irrigation and Dugwell irrigation system. The utilisation fertilizer under Pumpset irrigation system was found the highest in the sample followed by Tubewell and Dugwell. The fertilizer utilisation under Pumpset irrigation was about 8.6 kg per hectare in the combined sample region.

In addition, the utilisation of fertilizer under Tubewell and Dugwell irrigation system was about 6.9 kg per hectares. However, it was found that, utilisation of fertilizer under naturally flow waterways was only 4.3 kg per hectare. Thus, it is found that, availability of irrigation influenced the adoption of fertilizer in rice cultivation and systematic use of irrigation system may increase the fertilizer consumption in the sample.

Table 6.10: Consumption of chemical fertiliser in different irrigation system

| Name of the Villages | Naturally flow (kg/ha) | Irrigation equipments (kg/ha) | | | |
|---|---|---|---|---|---|
| | | Pumpset | Tubewell | Borewell | Dugwell |
| Hasaobari | 3.4 | 6.6 | 6.7 | 4.4 | 6.7 |
| Simlaguri | 3.6 | 8.8 | 4.3 | 5.6 | 4.3 |
| Gopdapara | 3.7 | 5.1 | 5.5 | 3.7 | 5.5 |
| Gengraypara | 4.7 | 9.0 | 6.0 | 5.7 | 6.0 |
| Dologaon | 3.9 | 7.8 | 5.0 | 4.9 | 5.0 |
| **Region 1** | **3.9** | **7.5** | **5.5** | **4.9** | **5.5** |
| Bautipara | 4.9 | 10.0 | 8.0 | 4.9 | 8.0 |
| Landanguri | 4.8 | 8.9 | 6.9 | 6.2 | 6.9 |
| Puradia | 4.8 | 10.1 | 7.9 | 4.8 | 7.9 |
| Baoraguri | 3.7 | 9.7 | 8.8 | 5.6 | 8.8 |
| Batabary | 5.7 | 10.3 | 9.9 | 5.7 | 9.9 |
| **Region 2** | **4.8** | **9.8** | **8.3** | **5.4** | **8.3** |
| **Total Sample** | **4.3** | **8.6** | **6.9** | **5.2** | **6.9** |

Source: Field Survey Data, 2012

### 6.4.3 Fertilizer Consumption and Rice Productivity

Fertilizer can produce higher yields per unit of land than without fertilizer. Although, rice is cultivated in a large land area in the sample the use of chemical fertilizer is found to be limited. Most of the farmers in the sample are still cultivating rice with organic manure. Moreover, some of the farmers are cultivating rice without using any fertilizer. To examine the impact of fertilizer on productivity, we have calculated the yield gap of rice (i) with chemical fertilizer and organic manure, (ii) chemical fertilizer and without fertilizer, and (iii) organic manure and without fertilizer. The estimated yield gap of rice is presented Table 6.11. The yield gap of rice between fertilizer utilization and organic manure was 225.4 kg per hectare in the combined sample region.

Table 6.11: Consumption of fertiliser and productivity of rice

| Name of the Villages | Productivity with fertiliser | | | Yield gap of | | |
|---|---|---|---|---|---|---|
| | Chemical | Organic | without fertiliser | chemical to organic | chemical to without fertiliser | organic to without |
| Hasaobari | 1423.2 | 1232.8 | 923.2 | 190.4 | 500.0 | 309.6 |
| Simlaguri | 1683.3 | 1387.9 | 909.3 | 774.1 | 774.1 | 478.6 |
| Gopdapara | 1512.9 | 1498.5 | 1022.3 | 14.4 | 490.6 | 476.2 |
| Gengraypara | 1406.6 | 1307.2 | 1099.0 | 99.4 | 307.6 | 208.2 |
| Dologaon | 1774.3 | 1359.3 | 998.0 | 415.0 | 776.3 | 361.3 |
| **Region 1** | **1560.1** | **1393.1** | **990.4** | **166.9** | **569.7** | **402.8** |
| Bautipara | 1815.6 | 1436.3 | 1018.3 | 379.3 | 797.3 | 418.0 |
| Landanguri | 1611.2 | 1521.6 | 1102.5 | 89.6 | 508.7 | 419.1 |
| Puradia | 1784.3 | 1365.8 | 997.5 | 418.5 | 786.8 | 368.3 |
| Baoraguri | 1730.4 | 1467.9 | 981.3 | 262.5 | 749.1 | 486.6 |
| Batabary | 1806.7 | 1537.6 | 1054.5 | 269.1 | 752.3 | 483.1 |
| **Region 2** | **1749.6** | **1465.8** | **1030.8** | **283.8** | **718.8** | **435.0** |
| **Total Sample** | **1654.9** | **1429.5** | **1010.6** | **225.4** | **644.3** | **418.9** |

Source: Field Survey Data, 2012

On the other hand, the yield gap between chemical fertilizer and without fertilizer was found to be more. The yield gap of rice between chemical fertilizer and without fertilizer was about 644.3 kg per hectare. Moreover, the yield gap between organic manure and without fertilizer was 418.9 kg per hectare in the combined sample regions. Thus, it is found that the productivity of rice with chemical fertilizer produced more kg per hectare than without fertilizer. This indicates that, systematic use of fertilizer in rice cultivation may increase the overall rice production in the sample by increasing productivity per hectare of land.

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### 6.5 Irrigation and Utilisation of HYVs

Adoption of high yielding varieties is mostly dependent on availability of irrigation system, availability of credit, farm size, etc. This is evident from several previous studies. Parthasarathy and Prasad (1971) observed considerable difference in the rates of adoption of modern rice varieties between the dry and the wet seasons. They further found that, adoption of high yielding varieties rice were more in irrigated wet land as compared to the un-irrigated land. Barker (1970) made an attempt to examine the impact of irrigation on the adoption of

HYVs rice. The author observed the large difference in area planted to modern varieties between the wet and the dry seasons. Most of the HYVs rice was found to be cultivated in the wet season. Thus, it is evident that modern varieties, rice is more suitable for the wet season as compared to the dry season. Chattapadhyay (1986) also found the similar conclusion from his study in West Bengal. According to his study, the utilisation of modern varieties of paddy is appropriate only in the presence of available irrigation facility. The adoption of modern rice varieties will not have an effect on productivity in the absence of available irrigation system. Thus, according to him adoption of modern paddy varieties may improve with available irrigation along with other factors. Anden and Barker (1971) further observed that the HYVs are better suited in salinity, drought, and flooding and deep water condition. Moreover, it was found that it is possible to raise HYVs rice only by improving irrigation system. Bezbaruah (1994) said that availability of irrigation facilities has been found to be an important favourable factor for adoption of modern varieties in the dry season. However, irrigation is crucial factor for adoption of modern rice varieties. George and Chaukidar (1972) made a comparative analysis on utilisation of modern varieties seeds in irrigated and un-irrigated areas in West Godavari District of Andhra Pradesh. The study found that the cultivation of modern varieties of rice was confined to the delta areas having adequate irrigation facilities. Sen (1974) have found irrigation to be a far more important factor than farm size or tenancy in explaining the uneven diffusion of new varieties among farmers. Thus, it is found that the irrigation is one of the most important factors which affect the adoption of high yielding varieties of rice positively.

On the other hand, the HYVs influence the yield level of the rice crop in the sample. It is generally observed that HYV seeds can give yield level higher than traditional varieties. There are several studies in the literature which explains the impact of HYVs and other factors on yield of rice. Studies of Basker (1970), Ballabh and Sharma, (1987), Kumar and Rosegrant (1994), Nkonya and Norman (1997), Tikkiwal and Tikkiwal (1998), Othman and Jusoh (2001), Siju and Kombairaju (2001), Singh and Kalra (2002), Saha, (2004) Zhou et al. (2010) and Singha (2011) observed that adoption of HYVseeds can give yield level double the yield level of the traditional paddy (see details in chapter 1 review section). Therefore, in this section an attempt has been made to examine the impact of high yielding varieties on yield of rice in the sample with the help of field survey data.

### 6.5.1 Adoption Patterns of HYVs in the Sample

Accordingly, the adoption pattern of HYVs rice of the sample farmers is presented in Table 6.12. According to data collected from a sample, out of total sample households only 109 (34.8 %) sample households were found adopting HYVs rice in the combined sample. Of which 53 households (39.6%) were found in region 1 and 56 households (30.1%) were in region 2. On the other hand, about 65.2 percent were found to cultivation tradition varieties of rice in the sample. Area under high yielding varieties in different seasons is presented in Table 6.13. As stated earlier, rice is cultivated in three main seasons in the sample. The adoption of HYVs rice also differs across seasons. According to our data, the adoption of HYVs rice was found to be more in summer season followed by autumn and winter season. Although rice is cultivated in the vast area during the winter season, yet the adoption of modern varieties of rice accounted to be meager in terms of area. The area under HYVs rice during the winter season was only 13.9 ha (19.7 %) of total HYVs areas in the combined sample. The main reason for poor adoption of modern varieties of rice during winter season is due to heavy rainfall and flood washed away the standing crops.

Table 6.12: Number of households adopting of HYVs in sample

| Name of the Villages | No. of Households | | % of HH to total sample | |
|---|---|---|---|---|
| | HYVs | without HYVs | HYVs | without HYVs |
| Hasaobari | 12 | 18 | 40.0 | 60.0 |
| Simlaguri | 9 | 22 | 29.0 | 71.0 |
| Gopdapara | 4 | 8 | 33.3 | 66.7 |
| Gengraypara | 10 | 12 | 45.5 | 54.5 |
| Dologaon | 18 | 21 | 46.2 | 53.8 |
| **Region 1** | **53** | 81 | **39.6** | **60.4** |
| Bautipara | 12 | 16 | 42.9 | 57.1 |
| Landanguri | 11 | 31 | 26.2 | 73.8 |
| Puradia | 14 | 30 | 31.8 | 68.2 |
| Baoraguri | 10 | 34 | 22.7 | 77.3 |
| Batabary | 9 | 19 | 32.1 | 67.9 |
| **Region 2** | **56** | 130 | **30.1** | **69.9** |
| **Total Sample** | **109** | 211 | **34.8** | **65.2** |

Source: Same as in Table 6.2

Moreover, most of the modern varieties of rice are short in height. Rice cultivation in low-lying areas is submerged and is damaged if flood water continues to stay for long days. However, the adoption of modern varieties of rice was 34.1 percent in summer season, which accounted to be higher than the winter season in the combined sample region. During the summer season, the area under HYVs was found to be higher in region 2 as compared to region 1. Moreover, out of the total rice area about 24.3 percent areas were used for HYVs rice during autumn season.

Table 6.13: Area under of HYVs rice in different saesons (ha)

| Name of the Villages | Winter Rice | | Summer Rice | | Autumn Rice | |
|---|---|---|---|---|---|---|
| | Area in ha | % | Area in ha | % | Area in ha | % |
| Hasaobari | 13.2 | 17.3 | 21.6 | 28.3 | 21.7 | 28.5 |
| Simlaguri | 11.6 | 14.3 | 27.9 | 34.5 | 20.3 | 25.1 |
| Gopdapara | 13.7 | 22.0 | 19.1 | 30.5 | 14.5 | 23.1 |
| Gengraypara | 12.7 | 31.5 | 12.0 | 29.7 | 10.0 | 24.9 |
| Dologaon | 10.9 | 17.3 | 16.8 | 26.9 | 14.0 | 22.4 |
| **Region 1** | **13.4** | **20.5** | **33.5** | **30.0** | **27.7** | **24.8** |
| Bautipara | 14.6 | 20.2 | 29.0 | 40.1 | 19.0 | 26.3 |
| Landanguri | 13.8 | 13.5 | 37.9 | 36.9 | 21.9 | 21.4 |
| Puradia | 21.8 | 21.1 | 33.1 | 32.1 | 22.9 | 22.2 |
| Baoraguri | 17.7 | 18.0 | 39.7 | 40.2 | 20.8 | 21.1 |
| Batabary | 14.7 | 22.1 | 28.1 | 42.1 | 18.9 | 28.4 |
| **Region 2** | **14.4** | 19.0 | **36.7** | **38.3** | **30.5** | **23.9** |
| **Total Sample** | **13.9** | **19.7** | **35.1** | **34.1** | **29.1** | **24.3** |

Source: Field Survey Data, 2012

### 6.5.2 Area under HYVs in Winter Rice Cultivation

The Area of modern varieties of rice under different irrigation system is presented in Table 6.14. As stated above, there is no systematic irrigation system in the sample. Therefore, naturally flow waterways serve as the main source of irrigation in the sample, especially during rainy season apart from privately owned Pumpset, Tubewell and Borewell irrigation. The adoption of modern varieties of rice required assured irrigation facility. Thus, it is found that none of the farmers in the sample have adopted modern varieties of rice in rainfed condition. Assam in general and sample villages in particular receives a good sum of rainfall during winter season. As a result, the stream and tributaries supply secure irrigation water to sample farmers. With the help of these naturally flowing waterways, farmers cultivate HYVs rice in the sample. Accordingly, about 16.1 hectare of land areas under naturally flow waterways were utilized for HYVs rice in the sample region 1. Moreover, about 19.6 hectare areas under naturally flow waterways were cultivated HYVs rice in region 2 during the study period. Thus, total 35.8 hectares of HYVs rice areas are served by naturally flow waterways irrigation. In addition, about 35.1 hectares and 29.1 hectares HYVs rice areas were cultivated by Pumpset and Tubewell irrigation respectively in the combined sample regions. However, only 0.2 HYVs rice areas in region 1 were cultivated by Borewell irrigation. On the other hand, about 9.7 hectares HYVs rice during the winter season was cultivated by Borewell irrigation water in region 2. Thus, HYVs rice accounted about 21.2 percent of the total rice area during the winter season in the sample.

Table 6.14: Areas under HYVs rice in winter season (area in ha)

| Name of the Villages | Rainfed | Naturally flow | Modern irrigation equipments | | | Total HYVs areas |
|---|---|---|---|---|---|---|
| | | | Pumpset | Tubewell | Borewell | |
| Hasaobari | Nil | 3.2 | 3.6 | 2.7 | Nil | 9.5 |
| Simlaguri | Nil | 1.6 | 2.9 | 2.3 | Nil | 6.8 |
| Gopdapara | Nil | 3.7 | 2.1 | 1.5 | 0.2 | 7.5 |
| Gengraypara | Nil | 2.7 | 3.0 | 1.0 | Nil | 6.7 |
| Dologaon | Nil | 4.9 | 3.8 | 2.0 | Nil | 10.8 |
| **Region 1** | **Nil** | **16.1** | **15.4** | **9.5** | **0.2** | **41.2** |
| Bautipara | Nil | 4.6 | 7.0 | 6.0 | 1.2 | 18.7 |
| Landanguri | Nil | 3.8 | 7.9 | 5.9 | 2.4 | 20.0 |
| Puradia | Nil | 1.8 | 5.1 | 6.9 | 2.8 | 16.6 |
| Baoraguri | Nil | 4.7 | 4.7 | 4.8 | 1.7 | 15.9 |
| Batabary | Nil | 4.7 | 6.1 | 3.9 | 1.6 | 16.3 |
| **Region 2** | **Nil** | **19.6** | **30.6** | **27.6** | **9.7** | **87.6** |
| **Total Sample** | **Nil** | **35.8** | **35.1** | **29.1** | **9.9** | **109.9** |

Source: Field Survey Data, 2012

### 6.5.3 Area under HYVs in Summer Rice Cultivation

The area under HYVs rice under different irrigation system during summer season is presented in Table 6.15. According to field survey data, about 380.6 hectares area under rice was brought under high yielding varieties during summer season. Out of which, about 186.2 hectares and 194.4 hectares were from region1 and region 2 respectively. The source-wise (irrigation) distribution of the HYVs rice area showed that only 13.9 hectares of HYVs rice areas were under naturally flow waterways in the combined sample regions. However, the area under HYVs rice under Pumpset irrigation was found to be the highest followed by Tubewell, Borewell and Dugwell.

Table 6.15: Areas under HYVs rice in summer season (area in ha)

| Name of the Villages | Naturally flow | Irrigation equipments | | | | Total area under HYVs |
|---|---|---|---|---|---|---|
| | | Pumpset | Tubewell | Borewell | Dugwell | |
| Hasaobari | 2.2 | 12.6 | 12.7 | 8.0 | 3.0 | 38.4 |
| Simlaguri | 2.6 | 11.9 | 12.3 | 7.3 | 3.3 | 37.4 |
| Gopdapara | 1.7 | 12.1 | 11.5 | 8.4 | 2.4 | 36.1 |
| Gengraypara | 1.7 | 13.0 | 11.0 | 5.6 | 3.6 | 34.9 |
| Dologaon | 2.9 | 13.8 | 12.0 | 7.3 | 3.3 | 39.4 |
| **Region 1** | **11.1** | **63.4** | **59.5** | **36.6** | **15.6** | **186.2** |
| Bautipara | 0.6 | 12.0 | 11.0 | 10.2 | 2.2 | 35.9 |
| Landanguri | 0.3 | 14.9 | 13.9 | 7.4 | 3.4 | 39.8 |
| Puradia | 0.8 | 13.1 | 12.9 | 9.8 | 2.8 | 39.4 |
| Baoraguri | 0.5 | 12.7 | 11.8 | 11.7 | 1.7 | 38.3 |
| Batabary | 0.7 | 11.1 | 13.9 | 11.6 | 3.6 | 40.9 |
| **Region 2** | **2.8** | **63.6** | **63.6** | **50.7** | **13.7** | **194.4** |
| **Total Sample** | **13.9** | **127.0** | **123.1** | **87.3** | **29.3** | **380.6** |

Source: Field Survey Data, 2012

On an average about, 127 hectares HYVs rice was under Pumpset irrigation system in the combined sample. Since, irrigation through Pumpset (diesel or electric), Tubewell, Borewell and Dugwell are secured as compared to naturally flow waterways, farmers are having more confidence to use HYVs rice under the such irrigation system. Moreover, almost all Pumpset, Borewell and Dugwell are privately owned by farmers themselves, they can use at any time whenever needed. Thus, it is found that creation of a proper irrigation system may increase the adoption, behaviour of HYVs rice during summer season in the sample.

### 6.5.4 Areas under HYVs in Autumn Rice Cultivation

The HYVs rice in autumn season is cultivated with the help of Pumpset, Tubewell, Dugwell, Borewell irrigation water in the sample. Areas under HYVs rice under different irrigation systems in autumn season is presented in Table 6.16. According to field survey data, about of

220.7 hectares of rice areas are occupied by HYVs in the combined sample. Out of which 117.1 hectares were in the region and 103.6 hectares were in region 2. Cultivation of HYVs rice under naturally flow waterways and rainfed were not found in the sample.

Table 6.16: Areas under HYVs rice in Autumn season (area in ha)

| Name of the Villages | Irrigation equipments | | | | Total HYVs area |
|---|---|---|---|---|---|
| | Pumpset | Tubewell | Borewell | Dugwell | |
| Hasaobari | 7.6 | 5.7 | 4.6 | 2.7 | 20.6 |
| Simlaguri | 6.9 | 7.3 | 7.9 | 3.2 | 25.3 |
| Gopdapara | 5.1 | 6.5 | 5.7 | 4.7 | 21.9 |
| Gengraypara | 7.0 | 7.0 | 8.5 | 2.9 | 25.4 |
| Dologaon | 9.8 | 6.0 | 4.5 | 3.5 | 23.9 |
| **Region 1** | **36.4** | **32.5** | **31.2** | **17** | **117.1** |
| Bautipara | 9.0 | 7.0 | 3.2 | 4.2 | 23.4 |
| Landanguri | 7.9 | 6.9 | 4.4 | 2.4 | 21.6 |
| Puradia | 5.1 | 5.9 | 2.8 | 2.8 | 16.7 |
| Baoraguri | 4.7 | 7.8 | 4.7 | 3.7 | 20.9 |
| Batabary | 6.1 | 9.9 | 3.6 | 1.6 | 21.2 |
| **Region 2** | **32.6** | **37.6** | **18.7** | **14.7** | **103.6** |
| **Total Sample** | **69.0** | **70.1** | **49.9** | **31.7** | **220.7** |

Source: Field Survey Data, 2012

Among different irrigation systems, cultivation of HYVs rice was found under Tubewell irrigation followed by Pumpset and Borewell. About 71.1 hectares HYVs rice areas during autumn season was cultivated by Tubewell irrigation system. Moreover, about 69 hectares HYVs rice areas were cultivated through Pumpset irrigation system. However, cultivation of HYVs rice under Dugwell was found least as compared to other irrigation systems in the sample. Only 31.7 hectares HYVs rice were cultivated by Dugwell irrigation.

### 6.5.5 HYVs Rice and Productivity

The HYVs rice can produce higher yields per unit of land than traditional varieties of seeds. It was also found that the HYVs rice can give yield level double the yield level of traditional varieties seeds in some places. Although, rice occupies the largest areas among individual crops in the sample, the use of HYVs are still not so popular among the sample. Most of the farmers in sample still cultivate traditional varieties of paddy. The main reasons behind the less adoption of HYVs of rice in the sample are due to not availability of irrigation facilities, lack of credit, higher cost of cultivation, etc. To examine the impact of HYVs on productivity, we have calculated the yield gap between irrigated and un-irrigated areas. The estimated yield gap and season wise productivity of rice is presented in Table 6.17. The yield gap between irrigated and un-irrigated in winter rice was 222.2 kg per hectare in the combined sample regions. On the other hand, the yield gap between irrigated and un-irrigated was found to be more in summer and autumn rice. The yield gap of summer rice was about 682.2 kg per hectare and autumn rice was 713.1 kg per hectare in the combined sample regions. According to the data given in the Table 6.12, the productivity of high yielding varieties of rice was found higher than traditional varieties of rice in all three rice growing seasons in the sample. The productivity of traditional rice was 1404.2 kg per hectare and HYV varieties rice was 1626.4 kg per hectares in winter season. Similarly, the productivity of traditional varieties of rice was 1107.2 kg per hectares and HYV rice were 1789.4 kg per hectare in summer season. In autumn season also, the productivity of HYV varieties (1759.6 kg/ha) of rice was higher than traditional varieties (1082.5 kg/ha) of rice in the sample. Thus, it is found that the productivity of HYV rice varieties can produce more kg per hectare of land than traditional varieties of rice in the sample. This indicates that, adopting modern varieties of rice can increase the overall rice production of the sample by increasing productivity.

Table 6.17: Season-wise utilisation of HYV seeds and productivity of rice

| Name of the Villages | Winter Rice (kg/ha) | | Yield gap | Summer Rice (kg/ha) | | Yield gap | Autumn Rice (kg/ha) | | Yield gap |
|---|---|---|---|---|---|---|---|---|---|
| | HYV Rice | Traditional | | HYV Rice | Traditional | | HYV Rice | Traditional | |
| Hasaobari | 1603.2 | 1301.5 | 301.7 | 1912.2 | 1002.5 | 909.7 | 1842.2 | 1016.5 | 825.7 |
| Simlaguri | 1583.3 | 1424.7 | 158.6 | 1803.3 | 1024.7 | 778.6 | 1823.3 | 1124.7 | 698.6 |
| Gopdapara | 1603.9 | 1326.9 | 277.1 | 1725.9 | 1103.9 | 622.1 | 1756.9 | 1233.9 | 523.1 |
| Gengraypara | 1516.6 | 1424.4 | 92.1 | 1808.6 | 1131.4 | 677.1 | 1832.6 | 1024.4 | 808.1 |
| Dologaon | 1664.3 | 1568.4 | 95.9 | 1764.3 | 1068.4 | 695.9 | 1731.3 | 968.4 | 762.9 |
| **Region 1** | **1594.3** | **1409.2** | **185.1** | **1802.9** | **1066.2** | **736.7** | **1797.3** | **1073.6** | **723.7** |
| Bautipara | 1615.6 | 1329.4 | 286.2 | 1905.6 | 1129.4 | 776.2 | 1895.6 | 1029.4 | 866.2 |
| Landanguri | 1681.2 | 1418.6 | 262.6 | 1741.2 | 1148.6 | 592.6 | 1767.2 | 1128.6 | 638.6 |
| Puradia | 1721.3 | 1308.4 | 412.9 | 1673.3 | 1123.4 | 549.9 | 1764.3 | 1148.4 | 615.9 |
| Baoraguri | 1630.4 | 1453.7 | 176.7 | 1845.4 | 1253.7 | 591.7 | 1812.8 | 1054.7 | 758.1 |
| Batabary | 1643.7 | 1486.1 | 157.6 | 1713.7 | 1086.1 | 627.6 | 1729.7 | 1096.1 | 633.6 |
| **Region 2** | **1658.4** | **1399.2** | **259.2** | **1775.8** | **1148.2** | **627.6** | **1793.9** | **1091.4** | **702.5** |
| **Total sample** | **1626.4** | **1404.2** | **222.2** | **1789.4** | **1107.2** | **682.2** | **1795.6** | **1082.5** | **713.1** |

Source: Same as in Table 6.2

## 6.6 Specification of Yield Response Model for Estimation

As stated earlier, the yield of rice is influenced by various factors like irrigation utilisation, area under HYVs, consumption of fertilizer, pesticides, marketing, transportation, prices, climatic and socio economic condition of farmers, etc. Although there are several factors that affect the productivity of rice, yet we have included only few variables such as HYVs rice, fertilizers and irrigation in the present study. The model was estimated for each season, i.e., winter rice, summer rice, and autumn rice. The basic objective is to examine econometrically how irrigation uses, the adoption of modern varieties of rice and fertilizer consumption influence the productivity of rice in different rice growing seasons. The yield response function can provide information about the direction and extent of the farmer's response to those factors. Most of the earlier yield response functions are based on the Nerlovian supply response function. Some of such studies are Cummings (1975), Narayana and Parikh (1981), Tikkiwal and Tikkiwal (1998), Goswami and Chatterjee (2006), Jin et al. (2012), Dutta (2011) etc. Many studies modified the basic structure of the Nerlovian model by including required exogenous variables in the model. Accordingly, in the present study, we have included three exogenous variables such as irrigation, area under HYVs of paddy and chemical fertilizer consumption. The estimation has been done only for the combined sample. The rice yield response function is written as:

$$\ln(\text{Rice})_t = \beta_0 + \beta_1 \ln(\text{HYVs})_t + \beta_2 \ln(\text{fertilizer})_t + \beta_3 \ln(\text{irrigation})_t + U_t$$

Where,

ln(rice) is natural log of rice yield in kg per hectare,

ln(fetiliser) is natural log of chemical fertilizer in kg per hectare of paddy area,

ln(HYVs) is natural log of HYVs seed applied per hectare a in kg

Ut is the random disturbance terms and $\beta 1$, $\beta_2$ and $\beta_3$ parameters to be estimated.

The coefficients of the variables are estimated by using the OLS method. The model has been estimated for the yield of total rice, summer rice, winter rice and autumn rice. The estimated results have been presented in Table 6.18. The model gives a reasonably good fit to the sample data in terms of $R^2$ value for all three seasons. Moreover, all three parameters of the function are found to be statistically significant.

Table 6.18: Estimated co-efficients of rice yield function in sample

| Inputs | Parameters | Yield of | | | |
|---|---|---|---|---|---|
| | | Winter rice | Summer rice | Autunm rice | Total rice |
| Constant | $\alpha_0$ | 6.156 (4.893)*** | 8.154 (6.964)*** | 7.193(12.046)*** | 7.496(13.407)*** |
| HYVs | $\alpha_1$ | 0.083 (1.964)* | 0.0149 (2.032)** | 0.028(2.654)*** | 0.215(2.086)*** |
| Fertiliser | $\alpha_2$ | 0.081 (1.415)* | 0.166 (1.883)** | 0.116(1.874)** | 0.186(2.987)** |
| Irrigation | $\alpha_3$ | 0.149 (6.130)*** | 0.347(4.448)*** | 0.287(8.067)*** | 0.287(4.765)*** |
| | $R^2$ | 0.92 | 0.68 | 0.78 | 0.87 |
| | N | 189 | 263 | 215 | 304 |
| | df | 185 | 259 | 211 | 300 |

Notes: t statistics values are given in parentheses, df=degree of freedom

*, ** and *** denote statistical significance at 10% level, 5% level and 1% level respectively.

**HYVs Rice:** The impact of HYVs variable on the yield of total rice and three seasonal rice crops was found to be positive and significant in explaining the variation of paddy yield in the combined sample during the study period. The estimated coefficient of HYV variable was found significant in all seasons, i.e., total rice, summer rice, winter rice and autumn rice. The positive and significant coefficient of HYV rice implies that a large proportion of rice acreage under HYV tends to raise the yield of rice. Among the estimated coefficients, winter paddy has the smallest coefficient. That is, the impact of expansion of area under the HYVs rice seeds for the winter rice seems to be the weakest among all seasons in raising the yield of winter rice. This may be due to excess rainfall and the consequent flood problems during the cultivation of sali rice. Many farmers feel reluctant to cultivate HYV paddy especially in low-lying flood prone areas, as many HYV paddy plants are short.

**Fertilizer:** The estimated results show that the impact of chemical fertilizer (kg/ha) on the yield of total rice yield was positive and statistically significant. The influence was statistically significant at 5 percent level of significance for all seasons except in winter rice. The influence of fertilizer in winter rice was found to be significant at 1 percent level of significance during the study period. Keeping all other factors constant, a one percent increase in the fertilizer consumption (kg/ha) led to an increase in rice yield by about 0.186 percent in the combined sample during the study period. The estimated results of the rice yield function in three different rice growing seasons also showed positive and significant impact of fertilizer consumption. However, the impact of fertilizer input was found to be the highest in case of summer followed by the autumn rice. Since the summer season is the dry season with no fear of being washed away by heavy rainfall or floods, many farmers can apply fertilizers more intensively during summer season. However, during winter season due to heavy rainfall, there is a fear of being washed away from one plot to another plot. Thus, the positive and significant coefficient of fertilizer indicates that higher the amount of fertilizers applied per hectare of rice area, the higher tends to be the yield of rice.

**Irrigation**: Like HYVs and fertilizer, the impact of irrigation on the rice yield, total and seasonal was found to be significantly positive in the sample. The influence was statistically significant at 1 percent level of significance for all seasons. Keeping all other factors constant, a one percent increase in the irrigation led to an increase in rice yield by about 0.287 percent in the combined sample. The estimated result of the rice yield function in three different rice growing seasons also showed positive and significant impact of irrigation.

Thus, the estimated yield function results show that all three explanatory variables such as irrigation, fertilizer and HYV seeds influenced the rice yield positively in the combined sample regions. This indicates that by increasing the appropriate dose of fertilizer consumption per hectare, systematic irrigation facilities and area under HYV seeds of paddy, rice yield in the sample villages may be increased further.

### 6.7 Main Findings and Summary

This chapter examined the impact of irrigation, fertilizer consumption and HYV seeds on the yield variation of seasonal paddy in the sample. A brief literature was done on the linkage of irrigation with rice productivity. Most of the empirical studies showed the positive correlation between irrigation and rice productivity. The yield response function was also estimated econometrically using the double log-linear function. It was done for all three seasons (winter, autumn and summer) along with the total rice. From the above discussions, following main findings can be drawn.

1. The productivity of rice was higher in irrigated area as compared to un-irrigated land in the sample. The average productivity of rice in irrigated land was 1772.86 kg/ha compared to 976.2 kg/ha in un-irrigated areas. Across seasons, winter (or sali) season is the most dominant. Due to suitable weather conditions and rainfall, most of the farmers cultivate sali rice in the sample.
2. The most commonly used irrigation sources in the sample are naturally flowing waterways and rainfall. Farmers were also using irrigation by pumpset, tubewell, borewell and dugwell. The cultivation of rice with irrigation equipments like pumpset, tubewell and borewell produced higher yield as compared to rainfed and naturally flowing waterways. Thus, variations on productivity of rice was observed in the sample locations depending on the types of irrigations.
3. The performance of privately owned irrigation systems was more efficient than other means of irrigation in enabling farmers to produce higher production and productivity. However, the cost per unit of land was higher for privately owned irrigation systems like pumpsets.

4. Availability of irrigation facilities influenced the adoption patterns of fertilizer in rice cultivation. Farmers were found to be applying more chemical fertilizers in controlled irrigation systems like pumpsets and tubewells than in rainfed conditions. This shows that higher level of assured irrigation systems may motivate the farmers to increase the fertilizer consumption.
5. The adoption level of HYV seeds in the sample is still low compared to other regions or even compared to overall Assam level. Only about 35 percent of farmers were found adopting HYV paddy seeds. This may be due to lack of knowledge or information about the HYV seeds or non-availability of modern seeds in the sample areas.
6. The estimated yield function results show that all three explanatory variables such as irrigation, fertilizer and HYV seeds influenced the rice yield positively and significantly in the combined sample regions. This indicates that by increasing the appropriate dose of fertilizer consumption per hectare, systematic irrigation facilities and area under HYV seeds of paddy, rice yield in the sample villages can be increased further.

# Chapter 7
# Summary and Conclusion

## 7.1 Introduction

Like many states in India, Assam is also an agrarian state. Therefore, the economy of Assam is largely dependent on the agriculture sector. It is a source of livelihood for a large number of populations of the state. According to the Economic Survey of Assam data 2014-15[1], about 75 percent of the population of Assam are dependent on agriculture for their livelihood. Moreover, agriculture sector provides employment to about 53 percent of the state's population. Since it provides livelihood to a large number of population, the land utilisation for agriculture purpose is very high in the state. Out of total geographical area about 30.16 lakh hectares of land areas are utilised for agricultural purposes in the state in 2011-12[2]. The soil and climatic conditions of Assam are congenial for agriculture, especially for rice cultivation. Since Assam lies in a high rainfall zone, the average rainfall in the state is very high as compared to other states of the country although it is not uniform. In addition to rainfall, the state also has abundant surface water and good groundwater resources. The state has good alluvial fertile soil favourable for irrigated agriculture. Thus, different kinds of crops in different seasons are grown in the state. Among all crops grown in the state, rice is the principal and dominant crop in terms of acreage share. Rice is the staple food of the state and it is consumed by almost 99 percent of the population as the main diet. Although, rice occupies the highest land areas, other crops like maize, wheat, jute, pulses, other food grains, rapeseed & mustard, seasum, sugarcane, potatoes, tapioca, linseed, tobacco, tea, etc. are also grown in the state. Apart from food crops, cash crops and commercial crops are also grown in the state. Tea, jute, oilseeds, sugarcane, cotton, tobacco, rape seed and mustard are the major cash crops which are grown in the state. Among cash crops, tea is the most famous and important crop grown especially in the upper Brahmaputra valley, north bank region and Cachar district.

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[1] Economic Survey of Assam Data 2014-15 indicate that "Agriculture sector provides employment of more than 50 percent of the total work force and more than 75 percent of the state populations are supported directly or indirectly through agriculture".

[2] "Agricultural Census of Assam, 2010-11"

Besides tea, jute and mesta are other important cash crops which are cultivated mostly in the central valley districts of Nagaon and the lower Brahmaputra valley.

Although the agriculture sector provides livelihood to a large number of population and generate employment for a large number of workforces, the agriculture sector is still facing several problems. The agriculture sector in Assam is still dominated by small and marginal farmers. The operational holdings in the state are highly skewed with more than 85 percent belonging to the lowest size classes. Out of total land holdings, about 18.31 lakh are marginal land holders, 4.97 lakh are small and 0.85 lakh are medium (Economic Survey of Assam, 2013-14). On the other hand, there is a small segment of the households consisting of big farmers with holding of more than 2 hectares in size in the state. The uneconomic sizes and scattered characters of the holdings present serious roadblocks for the achievement of a technological breakthrough in agriculture.

The state of Assam which lies in the high rainfall zone of the country is blessed with abundant rainfall. Although, the state usually receives good rainfall almost every year, it is not evenly distributed over time and space. This rainfall is, however, concentrated over a few months of the year. The rainfall in the state is mainly concentrated in the four monsoon months from June to September. The remaining eight months are generally dry. Even during monsoon, the rainfall is scanty and unpredictable in many parts of the state. Sometimes the monsoon is delayed considerably, while sometimes it ceases prematurely. Consequently, successful cultivation is not possible in large parts of the state without irrigation. This erratic nature of rainfall during monsoon creates twin problems of floods and drought in the state which makes kharif crops vulnerable. Thus, irrigation is crucial to agriculture as a primary source of water in the dry months of the year and to supplement rainfall in the monsoon season in the years of low rainfall.

Flood is one of the most important factors responsible for the stagnation of the agricultural production and productivity. Like any other states of India, the agriculture in Assam is prone to the vulnerability to natural hazards, particularly flood and drought. Of these twin problems of flood and drought, the problem of flood is the more devastating in its impact in the state since the intensity of flood occurrence is more. Drought is perhaps more challenging, but in frequency, extant and intensity flood is undoubtedly the more disastrous of the two natural calamities.

In addition, use of adequate and assured inputs such as technology, quality seeds, fertiliser, pesticides, implements and credit in the production process is very much important to increase the production and productivity. Their timely availability in adequate quantity near the farmers' fields is absolutely essential for agricultural production and productivity. Fertilizer is considered as one of the most essential inputs for the increased agricultural production. However, consumption of fertilisers in Assam is still very low. On an average, the fertiliser consumption of Assam was only 76.54 kg/ha which was much lower than the national average consumption of 135.09 kg/ha in 2008-13. Besides fertiliser, the uses of HYV paddy in Assam have increased over the years. The area under HYV paddy in Assam was only 1004 thousand hectares in 1990-91 which has increased to 1703 thousand hectares in 2012-13. It may be noted that though the area under HYV seeds and fertiliser consumption have been increasing over the years, the total area coverage is still very limited.

Credit is another most important input in agricultural practices. Agricultural credit provides the necessary means for access to inputs and technology to the agricultural producers. However, it has been observed that the various institutions which are associated with agricultural finance in Assam have not been able to perform their roles satisfactorily. Despite urgent credit needs among the agriculturalist, the demand for loans from these financial institutions is low. The credit delivery of Assam shows far below as compared to other states of India. The reason for poor credit delivery in Assam might be due to missing link between the arrangements of institutional credit the villages and its user agencies at the grass root level.

Another most important factor responsible for low development of agriculture sector in Assam is the lack of irrigation facility. Agricultural development depends to a great extent on the availability of adequate and assured irrigation facilities. The assured irrigation water, especially in the dry months is an imperative need for optimum utilisation of chemical fertilisers and HYV seeds. In addition, irrigation also enables crops diversification. Though, irrigation is very much important in the process of agricultural production, the development of irrigation in the state is still lagging behind as compared to other states of the country. The irrigation potential created through different schemes or different agencies shows clearly that, irrigation potential created in the state is far below as compared to other major agricultural states of the country. The potential utilisation from the created irrigation in the state is also very low as compared to other major agricultural states of the country. However, Assam still remains far behind the average all India level of irrigation development.

Thus, in the present study, an attempt has been made to examine the growth trends of irrigation potential created and utilisation with special reference to the Chirang district of Assam. Further, we have examined the seasonal variations of irrigation utilisation in the sample area to examine the impact of irrigation on the paddy crop yield in the sample. The specific objectives of the present study are:

(i) To examine the structure and development of irrigation in Assam,

(ii) To examine the utilization patterns of available irrigation facilities for paddy cultivation in the sample areas with the help of field survey data and

(iii) To examine the impact of available irrigation on seasonal paddy yield variations in the sample regions.

Relevant data for the present study were collected through both secondary and primary sources. The secondary data were collected to study the growth and development of irrigation systems in Assam. Time series data on irrigation, gross area irrigated, net area irrigated and area under irrigated rice and difference sources of irrigation were collected from sources like various issues of Statistical Handbook of Assam, Economic Survey of Assam, CMIE, publications of the Directorate of Economics and Statistics (Govt. of Assam and Govt. of India). In addition, the primary data were collected to get into more intensive information at the micro level. To collect primary data, ten sample villages of Chirang district in Assam were selected through the multistage sampling method. Primary data were collected at the household level using the systematic survey form.

The thesis was organized into seven chapters. The first chapter is the introduction chapter. This chapter deals with the introduction of the problem, motivation behind the present study, objectives, data sources and methodology. A brief review of literature on the irrigation development issues has also been given in this chapter. In chapter 2, an assessment of growth and trend of irrigation in Assam as compared to other states of the country is done with the help of available secondary data. Further, we have discussed briefly different sources of irrigation in the state. Chapter 3 is the description of field surveys and primary data collection. In this chapter, we have discussed the method of data collection, and selection of sample households. Chapter 4 describes the general profile of sample households where main items are on the demographic characteristics, occupational structure, and land use pattern, cropping pattern and irrigation sources. Chapters 5 and 6 form the main chapters of the thesis. The analysis of availability and utilization of irrigation among the sample households is made in chapter 5. Some of the important items examined in this chapter are availability and seasonal variations of irrigation in the sample, and the factors affecting the irrigation development in sample villages. Chapter 6 is on the discussion of how the irrigation is affecting the yield of paddy crops across seasons and across sample households. The yield response function was also estimated econometrically to examine the influence of irrigation, fertilizer and HYV area to the paddy yield for three seasons. Finally, chapter 7 provides the broad summary of the study and derives some policy implications.

### 7.2 Chapter-wise Main Findings

Chapter 2 discussed briefly the overview on the development of irrigation in Assam. Assam is considered one of the most water abundant states in the country. Apart from heavy rainfall during monsoon, the state has huge potential of water resources such as mighty river systems (viz., the Brahmaputra and Barak along with their tributaries), rich underground water, various ponds and lakes. But, only a small fraction of water resources has been utilized despite abundant water resources in the state. Accordingly, the ratio of gross irrigated area to gross cropped area is very low. A large portion of land under agriculture is un-irrigated in the state. Most of the farmers in the state are mostly dependent on rainfall for the crop cultivation. The irrigation department in collaboration with state ASMIDC and DAPRD has implemented various irrigation schemes in the state. Accordingly, total 13 major and medium irrigation projects have been implemented, and the construction of 7 major and medium irrigation projects are going on. Beside, the concerned authority has proposed to implement 7 more major and medium irrigation projects in the state. In addition to major and minor irrigation schemes, about 1017 minor irrigation projects were implemented through government schemes. Further, the construction of 1180 minor irrigation schemes is going on in the state. Thus, the potential irrigation created through government schemes was 447980 hectares in 2011-12. On the other hand, the potential utilisation created irrigation in the state was 117075.42 hectares in 2011-12. Thus, it is observed that the gross and net irrigated area in Assam is low as compared to other states of the country though Assam is richly endowed with water resources. Hence, the state of Assam exhibits the paradox of water scarcity inspite of water abundance. Constraints like technical, financial and institutional, and lack of knowledge of modern irrigation facilities are some of the factors responsible for the low irrigation development in Assam.

Chapter 5 discussed the availability and utilisation of irrigation facilities for paddy in the sample regions in Assam. Some important points emerged from the data analysis are given below:

1. Rainfall and naturally flowing waterways are the main sources of irrigation for paddy cultivation in the sample region.
2. Out of total gross cropped area, only 43.9 percents area under paddy cultivation are irrigated in the combined sample regions. Of these, about 49.4 percent is irrigated through irrigation equipments such as Pumpsets, Borewells, Tubewells, etc. On the other hand, about 50.6 percent areas under paddy cultivation were irrigated by naturally flowing waterways.
3. The field study also found the existence of modern irrigation equipments such as Pumpsets, Borewells, and Tubewells in the sample. But utilisation of the systematic irrigation system such as canal irrigation, drip irrigation, sprinkle irrigation, etc. were found nil during the study period.
4. The source-wise availability of irrigation in the sample shows that about 22.2 percent of the area under paddy cultivation was served by naturally flowing waterways. On the other hand, 13.1 percent areas are served by pumpsets irrigation system followed by Tubewells (3.4 %,) Borewells (3.2 %) irrigation systems.
5. Season-wise irrigation utilisation showed that sali rice (winter rice), which is cultivated during June-July and harvested in November-December, is mostly cultivated through naturally flowing waterways and rainwater. About 46.2 percent

of areas under sali rice was cultivated by naturally flowing waterways during the study period.

6. Out of total gross cropped area, about 28.7 percent of Boro rice areas were cultivated through Pumpset irrigation system in the combined sample. Since, ground water level goes down and water of river, tributaries and stream dries up during the summer season, very few farmers could use naturally flowing waterways for Boro rice cultivation.
7. Ahu rice which is cultivated in autumn season is mostly cultivated with the help of modern irrigation equipments rather than rainfall and naturally flowing waterways. During this season, most of the farmers used pumpset irrigation to cultivate Ahu rice in the sample. On an average, about 39.4 percent areas under Ahu rice cultivation was irrigated by pumpset irrigation system in the sample during the study period. Other than Pumpset irrigation, farmers also used Dugwells, Borewells, Tubewells and partly by naturally flow waterways for Ahu rice cultivation.
8. There are various reasons for poor irrigation development and poor utilisation of created irrigation in the sample. Factors such as poor economic conditions of farmers, lack of awareness about modern irrigation equipments, frequent floods and water logging during rainy season, electricity shortage, and institutional problems are some of the main factors responsible for poor irrigation development in the sample region.

Chapter 6 examined the mainly the impact of irrigation on the paddy yield using the sample data. It also examined the impact of fertilizer consumption and HYV seeds on the yield variation of seasonal paddy in the sample. A brief literature was done on the linkage of irrigation with rice productivity. The yield response function was also estimated econometrically using the double log-linear function. It was done for all three seasons (winter, autumn and summer) along with the total rice. From the above discussions, following main findings can be drawn. (i) The productivity of rice was higher in irrigated area as compared to un-irrigated land in the sample. The average productivity of rice in irrigated land was 1772.86 kg/ha compared to 976.2 kg/ha in un-irrigated areas. Across seasons, winter (or sali) season is the most dominant. Due to suitable weather conditions and rainfall, most of the farmers cultivate sali rice in the sample. (ii) The most commonly used irrigation sources in the sample are naturally flowing waterways and rainfall. Farmers were also using irrigation by pumpset, tubewell, borewell and dugwell. The cultivation of rice with irrigation equipments like pumpset, tubewell and Borewell produced higher yield as compared to rainfed and naturally flowing waterways. Thus, variations on productivity of rice were observed in the sample locations depending on the types of irrigations. (iii) The performance of privately owned irrigation systems was more efficient than other means of irrigation in enabling farmers to produce higher production and productivity. However, the cost per unit of land was higher for privately owned irrigation systems like pumpsets. (iv) Availability of irrigation facilities influenced the adoption patterns of fertilizer in rice cultivation. Farmers were found to be applying more chemical fertilizers in controlled irrigation systems like pumpsets and tubewells than in rainfed conditions. This shows that higher level of assured irrigation systems may motivate the farmers to increase the fertilizer consumption. (v) The adoption level of HYV seeds in the sample is still low compared to other regions or even compared to overall Assam level. Only about 35 percent of farmers were found adopting HYV paddy seeds. This may be due to lack of knowledge or information about the HYV seeds or non-availability of modern seeds in the sample areas. (vi) The estimated yield function results show that all three explanatory variables such as irrigation, fertilizer and HYV seeds influenced the rice yield positively and significantly in the combined sample regions. This indicates that by increasing the appropriate dose of fertilizer consumption per hectare, systematic irrigation facilities and area under HYV seeds of paddy, rice yield in the sample villages can be increased further.

Thus, some of the main findings of the present study are (i) the most widely used sources of irrigation for paddy cultivation in the sample area were rainwater and naturally flowing waterways, (ii) the yield of paddy was higher in controlled irrigation conditions of pumpsets and tubewells than under rainwater or naturally flowing waterways and (iii) The yield of summer paddy was found to be the highest compared to the winter and autumn paddy.

### 7.3 Policy Implications and Suggestions

Above findings have enormous importance on the policies to increase the rice productivity as well as overall agricultural development in the state. In this perspective, following suggestions can be made.

First, there is a huge practice of summer paddy cultivation in summer season in the sample. But there are no adequate irrigation facilities during this season. Similarly, rainfall during this season is less and cultivation of summer rice is very much dependent on the availability of assured irrigation facilities. In our study, it is found that only those farmers who can afford costly pumpset and who can access by extracting natural flowing waterways are cultivating paddy during summer season. Therefore, government should take proper steps to increase the supply of irrigation equipments such as Pumpsets and Tubewells. There should be an emphasis on the minor irrigation schemes which are cheap and accessible to many farmers. Systematic co-ordinations should be there between users and providers of irrigation facilities. Water from naturally flowing waterways can be better harnessed by constructing small dams in involving farmers.

Secondly, maintenance of existing long government canals (*dong)* distributory channels should be repaired. This will help in proper distribution of irrigation water from the already created irrigation potential.

Thirdly, the participatory irrigation or watershed management committees should be formed in every village or in groups of villages. During the field surveys, no such participatory irrigation management committee was found among farmers. The committee can take care of the maintenance of small dams and distributory channels.

Fourthly, the concerned irrigation department or extension workers should also provide proper awareness about the benefits of use of irrigation water. Since many farmers are not aware of the modern irrigation facilities, they are not able to harvest the benefits of the already created irrigation facilities. This is one of the reasons behind the gap between irrigation potential created and irrigation potential used.

### 7.4 Limitations and Future Scope

The present study suffers from some limitations. The first problem is the data problem. The getting district-wise time series data on irrigation was difficult mainly for the newly formed district like Chirang. Therefore, the study was restricted to some districts only and only for few years for which secondary data were available. Due to lack of district-wise data, the analysis could not be carried out extensively with the help of secondary data, especially at the district level.

Second limitation is the sample size for the primary survey data. The present study included only 320 sample households from ten villages from Chirang district of Assam. The stated objectives of the present study are examined with data from these ten villages only. Inclusion of larger number of sample villages or households in different districts or states might have given more information on the variations in the creation and utilization of irrigation. Besides, the inclusion of more sample villages could have enabled the researcher to draw better conclusions. This can be taken up in future research. Moreover, in our field survey, many farmers were found to be willing to cultivate paddy during summer season for various reasons. But the main constraint faced by many sample farmers is the lack of assured irrigation facilities during summer. This type of research can also be carried out to examine what factors are motivating farmers or what constraints are not allowing farmers to cultivate summer paddy.

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