

Dairy Productivity and Crossbreeding Technology Adoption in Assam: Impact and Determinants

A thesis submitted to Indian Institute of Technology Guwahati
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy



By

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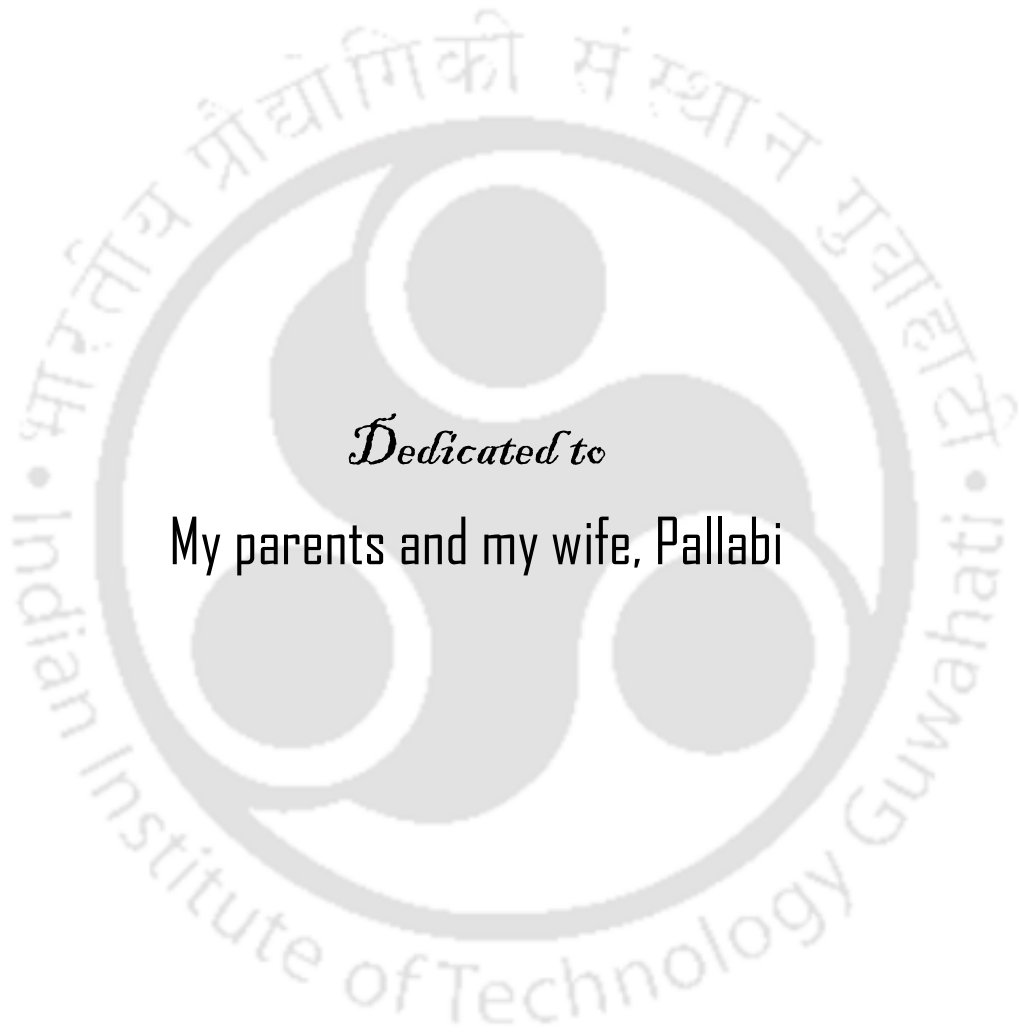


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Dedicated to
My parents and my wife, Pallabi



Indian Institute of Technology Guwahati

Department of Humanities and Social Sciences

Guwahati-781039, Assam, India

Declaration

I hereby declare that the thesis entitled “**Dairy Productivity and Crossbreeding Technology Adoption in Assam: Impact and Determinants**” is my original research work carried out in the Department of Humanities and Social Sciences, Indian Institute of Technology Guwahati, India, under the supervision of Dr. Mrinal Kanti Dutta, Professor (Economics), Department of Humanities and Social Sciences, IIT Guwahati.

In keeping with the general practice of reporting scientific observations, due acknowledgement has been made wherever the work described is based on the findings of other investigations.

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Certificate

This is to certify that the thesis entitled “**Dairy Productivity and Crossbreeding Technology Adoption in Assam: Impact and Determinants**” submitted by Mr. Baban Bayan for the degree of Doctor of Philosophy in Economics in the Department of Humanities and Social Sciences, Indian Institute of Technology Guwahati, embodies bonafide record of research work carried out under my supervision and guidance. The collection of materials/data from the secondary and primary sources has also been done by Mr. Baban Bayan himself. All assistance received has been duly acknowledged.

The present thesis or any part thereof has not been submitted to any other University for the award of any degree or diploma.

(Dr. Mrinal Kanti Dutta)

Supervisor

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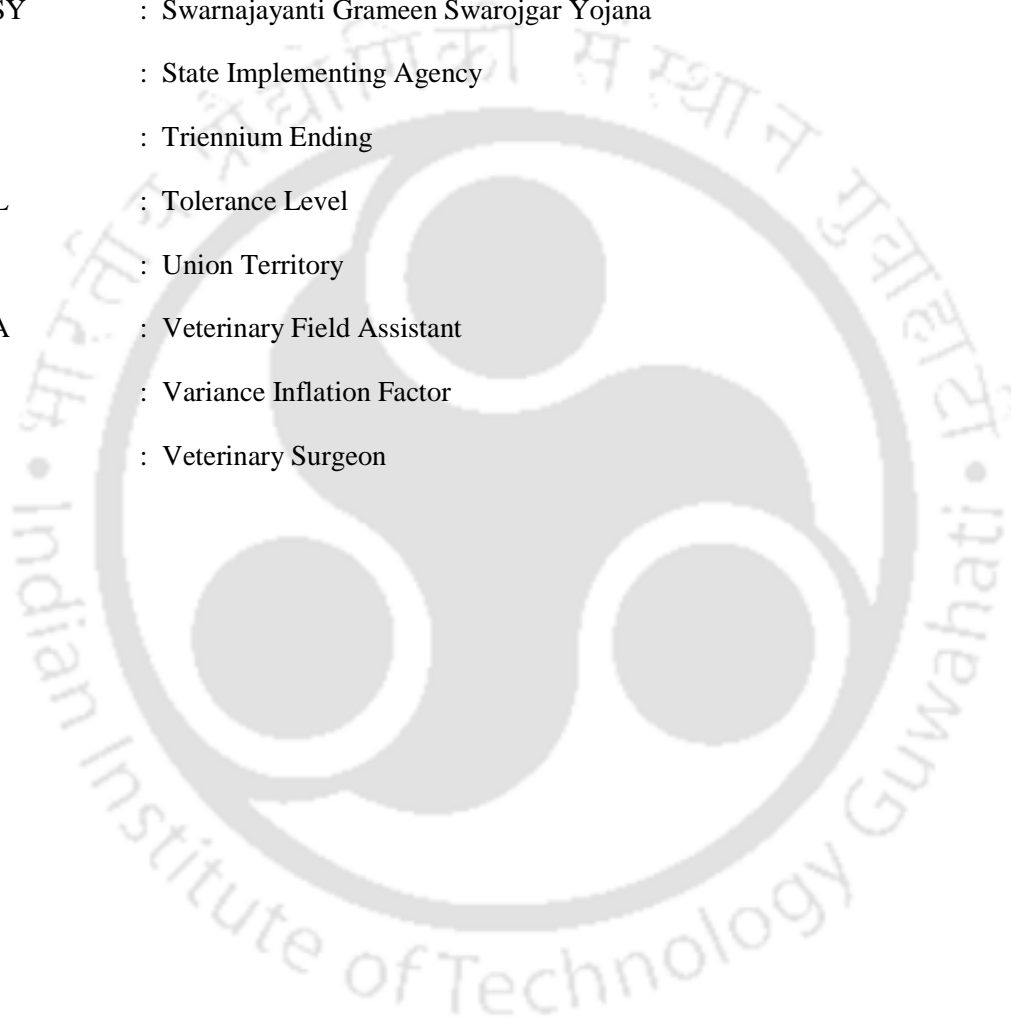
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Abbreviation

AAU	: Assam Agricultural University
AI	: Artificial Insemination
AIC	: Akaike's Information Criterion
ALDA	: Assam Livestock Development Agency
ARIASP	: Assam Rural Infrastructural and Agricultural Services Project
ATT	: Average Treatment Effect on the Treated
BIC	: Bayesian Information Criterion
BPL	: Below Poverty Line
BR	: Bias Reduction
BTAD	: Bodoland Territorial Area District
CCBF	: Central Cattle Breeding Farm
CDB	: Community Development Block
CDF	: Cumulative Distribution Function
CFSPTI	: Central Frozen Semen Production and Training Institute
CIA	: Conditional Independence Assumption
CPR	: Common Property Resource
DCS	: Dairy Cooperative Society
DVO	: District Veterinary Officer
FAO	: Food and Agriculture Organization
FGD	: Focus Group Discussion
FIAPO	: Federation of Indian Animal Protection Organization
FS	: Frozen Semen
FSB	: Frozen Semen Bank
GDP	: Gross Domestic Product
GM	: Gopal Mitra

GoI	: Government of India
HF	: Holstein Friesian
HH	: Household
ICDP	: Intensive Cattle Development Project
ILRI	: International Livestock Research Institute
IV	: Instrumental Variable
IVRI	: Indian Veterinary Research Institute
KBM	: Kernel Based Matching
KVS	: Key Village Scheme
LN	: Liquid Nitrogen
LR	: Likelihood Ratio
MASB	: Mean Absolute Standardized Bias
MSP	: Minimum Standard Protocol
NDDB	: National Dairy Development Board
NDRI	: National Dairy Research Institute
NE	: North East
NNM	: Nearest Neighbour Matching
NPBBDD	: National Programme for Bovine Breeding and Dairy Development
NPCBB	: National Project on Cattle and Buffalo Breeding
NS	: Natural Service
NSSO	: National Sample Survey Organization
OLS	: Ordinary Least Square
PD	: Pregnancy Diagnosis
PDF	: Probability Density Function
PSM	: Propensity Score Matching
RAIC	: Regional Artificial Insemination Centre

RBQ	: Rank Based Quotient
RKVY	: Rashtriya Krishi Vikash Yojana
RM	: Radius Matching
RS	: Red Sindhi
SAU	: Standard Animal Unit
SGSY	: Swarnajayanti Grameen Swarojgar Yojana
SIA	: State Implementing Agency
TE	: Triennium Ending
TOL	: Tolerance Level
UT	: Union Territory
VFA	: Veterinary Field Assistant
VIF	: Variance Inflation Factor
VS	: Veterinary Surgeon





Abstract

Crossbreeding of cattle using artificial insemination (AI) considered as the most significant and economically viable technique has emerged as an important strategy to increase dairy productivity. The strategy has become of particular importance in a state like Assam in North-East India due to the high density of low yielding indigenous cattle in the state. In view of the fact that dairying is an important livelihood option for a vast segment of the rural population in the state, productivity enhancement of the local cattle stock may improve the welfare of the smallholder farmers in the state. Latest Livestock Census Report, 2012 reveals that the crossbred cattle population in the state is 3.84 per cent against the national average of 20.81 per cent necessitating intervention in the diffusion of crossbreeding technology in the state. With this backdrop, the study has been conducted to understand crossbreeding technology diffusion and corresponding bovine population and milk production dynamics; to understand the effect of cattle crossbreeding on wellbeing of the farmers ; to examine the determinants of crossbreeding technology (AI) adoption at farmers' level; and farmers' perception on constraints in dairying with adoption of crossbreeding technology.

The study makes use of both primary and secondary data. Secondary data are used mainly to examine the cattle crossbreeding scenario in the state and the corresponding changes in the composition of bovine population and milk production. In order to understand underlying issues of milk production and productively and impact and determinants of crossbreeding technology adoption, the study has used primary data collected from 245 respondents from three districts of Assam, viz. Barpeta, Sonitpur and Karbi Anglong. Multistage sampling technique is followed for selection of the sample farmers for primary survey. The crossbreeding technology diffusion, bovine population and milk production dynamics and underlying issues of milk production and productivity are analyzed using simple statistical tools such as percentage, ratio and average, and wherever necessary multiple regression technique is employed. The wellbeing impact of crossbred cattle adoption is examined using semi-parametric technique, namely propensity score matching (PSM). The determinants of crossbreeding technology adoption are analyzed using Double-Hurdle model where adoption decision and extent of adoption is examined using Probit and Truncated Regression model

respectively. The ranking of constraints perceived by the sample farmers towards adoption of crossbreeding technology is done using Rank Based Quotient (RBQ) technique.

The dairy productivity and production characteristics of the sample farmers reveal that crossbred cattle are superior to indigenous cattle in terms of lactation and reproduction characteristics. It is also found that adoption of crossbred cattle has favourable impact on raising marketed surplus and farm profitability considering several other control factors. The impact estimates based on Propensity Score Matching indicate that crossbred cattle adoption has higher wellbeing impact in terms of income, consumption of high value commodities and employment (labour use effect). The results indicate that total household income after adoption of crossbred cattle significantly increases in the range of Rs 46,299.54 to Rs 54,389.08 for alternative matching algorithms over the counterfactual non-adopters. Disaggregating the total household income according to sources the net dairy income is found to be the dominant source rising significantly in the range of Rs 44,573.03 to Rs 44,904.27 over the net dairy income of farmers with only the non-descript cattle. The treatment impact of net dairy income per milch cattle per day of crossbred cattle adopters increases in the range of Rs. 42.06 to Rs. 42.21 compared to the matched non-adopters. Consumption of high value commodities indicates that adopter households have significantly higher average per capita daily consumption of milk and milk products by a range of 105.87 to 109.55 grams and meat consumption in the range of 6.51 to 8.40 grams over the counterfactual non-adopters. The study shows that adopters have statistically significant increase in total labour use after high yielding crossbred cattle adoption equivalent to the range of 10.27 to 10.55 person days per month in relation to matched non-adopters of crossbred cattle pointing out the employability prospect of cattle crossbreeding. The significant rise in total monthly person days is also evident for both male and female workers.

The results of Double-Hurdle model indicate that education of the household head and amount of land allotted for fodder cultivation affects positively the decision to adopt crossbreeding technology (AI). There is a positive and significant relation between credit access and extent of crossbreeding technology adoption. Physical environment characteristics such as distance from farm household to market and all-weather road affect

adoption of AI technology negatively. The study has also found 'availability of grazing land' and 'beneficiary of existing dairy development programmes' as positive and significant factors influencing adoption decision of AI technology. A negative significant relationship between number of years starting the dairy farm and adoption and extent of adoption of artificial insemination technology is found indicating that relatively new farms are significantly affected more towards adoption and extent of adoption. Relationship between distance to AI centre adoption and extent of adoption is positive and significant implying that AI services are mostly carried out at farmers' door step. Access to local breeding bull negatively influences both adoption and extent of adoption of AI. Farmers with bigger herd sizes are adopting crossbreeding technology more but further increase in the herd size is found to negatively affect the intensity of adoption of the technology indicating that constraints may appear with larger herd sizes. Number of years since knowing about AI is taken as a proxy to extension effort and awareness programme. The results show that farmers knowing about AI much before are more likely to adopt and increase the intensity of use of AI technology. It is also found that the chances of adoption and extent of adoption reduced for those farmers who consider artificial insemination technology to be risky. Again, adoption and use intensity of crossbreeding technology is contingent upon various breeding, feeding, management and socio-psychological constraints perceived by the sample farmers. Prominent among these constraints are the high cost of rearing crossbred cattle due to higher cost of feed and fodder and difficulty in getting green fodder, higher requirement of care and management by the crossbred cattle, lack of knowledge on recommended management practices while rearing crossbred cattle etc.

Based on the findings, the study suggests that intervening in rural education may influence positively the adoption of crossbreeding technology among smallholder farmers in Assam. It is also suggested that easy availability of credit facility may encourage the intensification of AI technology among the dairy farmers in the state. The finding recommends that facilitating the farmers with dairy development programmes such as subsidized feed and green fodder seed distribution may help to motivate farmers towards adoption of AI. Furthermore, deployment of more AI technicians in the rural areas of the state and castration of local breeding/scrub bull will help in increasing the adoption rate of AI technology. If risk

perception of the farmers can be reversed through better extension services and awareness programme, the rate of adoption and use intensity of AI are likely to increase in the state.



CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Global markets for livestock products are growing rapidly. It is estimated that the demand for livestock products will double by the year 2020 (FAO, 2013). A significant proportion of this rising global demand is expected to come from developing countries due to rising income, growing urbanization and population growth (Brown et al., 1999; Sharma, 2004; Birthal and Rao, 2004; FAO, 2006; Kumar et al., 2007). According to Dalal and Pathak (2010), demand side factors such as urbanization and per capita income have stronger influence on production of milk, the most important component of livestock products.¹ As agriculture becomes more commercialized, the consumption pattern in the rural areas too undergoes changes due to growth in income and development of close cultural links of the rural areas with the urban centres (Sidhu and Bhullar, 2004). Milk and milk products being highly income elastic, there seems to be a tendency to experience significant spike in the volume of milk business. As Singh and Dutta (2013) report, the distribution of dairy cattle is far more equal among the farm households than that of farm land suggesting that with efficient input and output support services, dairying can serve as a major economic activity for the small, marginal and landless farmers. Hence, encouraging the dairy enterprise may have a tendency to ensure equitable distribution of income.² With the increase in the demand for milk and subsequent effect on intensification in the dairy activities, it is likely to have economic wellbeing impact on the small and marginal farmers through rising income, employment and consumption.

Emerging trends indicate that the annual demand for milk in India has been growing at a very rapid rate and is likely to be 200-210 million tons by 2021-22 (NDDDB, 2011). Milk is one of the most important tradable commodities across state and international borders in Indian context as evident from the fact that India is the world's top milk producer accounting for about 13 per cent of the world milk production (Saha and Jain, 2004). Currently, dairying contributes about 27 per cent of agricultural GDP and 4.35 per cent of

the national GDP in India (GoI, 2007-08). Approximately 70 million rural households in India (primarily small and marginal farmers and landless labourers) are engaged in milk production (FIAPO, 2010; Kurup, 2011). Hence, the dairy subsector bears remarkable importance in the Indian economy, not only as a contributor to the national GDP of the country but also as a potential sector to provide a source of livelihood opportunity to a vast segment of the population. The dairy subsector has an enormous employment potential because livestock rearing is a highly labour-intensive activity. Milk and milk products are a source of high protein food that supplement nutritional security of the population (Dastagiri, 2003). There has been a continuous decrease in employment in the crop sector since the mid-eighties due to intensive and extensive use of tractors and harvesting combines and greater use of herbicides (Sidhu and Bhullar, 2004) leaving a large reserve army as a source of cheap labour for the dairy sector. Milk production is primarily a supplementary occupation for small landholders or landless labourers (FIAPO, 2010; Sharma, 2004). Dairying in India is more inclusive compared to crop production in the sense that it involves a majority of the vulnerable segments of the society for livelihoods (Singh and Dutta, 2013). From being a recipient of massive material support from the World Food Programme and European Economic Community in the 1960s and early 1970s, India has rapidly positioned itself as the world's largest milk producer during the 2000s. An increase in productivity has resulted in significant increase in milk production from 17 million tons at the beginning of the First Five Year Plan (1951) to 127.9 million tons at the end of the Eleventh Plan (2011-12) in India.

India is one of the highest bovine density countries in the world. On an average, every hundred hectares of cropped area in the country supports about 151 bovines (104 cattle and 47 buffaloes) (Sharma, 2004). However, compared to many developed countries it has very low milk productivity. In fact, low productivity has been a major problem of Indian dairying for a long time (Saha and Jain, 2004). While the demand for milk has been rapidly increasing with change in consumption pattern towards more high value commodities like milk both in rural and urban areas due to rise in income, the productivity of the dairy subsector has not increased significantly. According to Dalal and Pathak (2010), the ability of the milk production system to respond to the demands of productivity enhancement depends upon the country's proficiency in addressing the issues of technology transfer,

genetic improvement, feed and fodder supply and livestock healthcare service delivery. The introduction of crossbred cows could be a suitable development option for farm households with little or no land, provided that these households have access to feed sources (Patil and Udo, 1997). Chandel and Malhotra (2006) further remark that milk productivity can be increased by laying emphasis on improving breed of bovine and its nutritional intake.

Crossbreeding of Indigenous cattle with exotic germ plasm is an important component of dairy development strategy in India (Bhowmik, 2006; Chandel and Malhotra, 2006; Udo et al., 2011). This is particularly due to the fact that grazing land are continuously shrinking and demand for milk is rising creating the necessity of more stall fed productive cattle. Progressive replacement of the indigenous cattle population by crossbreds and cows of developed Indian dairy breeds would reduce overall cattle numbers and improve sustainability; crossbreeding of nondescript indigenous cattle is thus a major solution to India's oversized cattle population (Kurup, 2002). In India, crossbreeding programme was implemented on a large scale with the introduction of Intensive Cattle Development Project (ICDP) in 1963 as a special development programme in Third Five Year plan period (Rao et al., 1995). The central and state governments started dairy development extensively through crossbreeding in the 1970s (Udo et al., 2011). As Sharma (2004) states, the government of India had initiated major policy changes in the dairy sector during the late 1960s to achieve self-sufficiency in milk production. This policy initiative gave boost to dairy development and initiated the process of establishing the much needed linkages between rural producers and urban consumers. Dastagiri (2003) remarks that technological progress in production is central to the positive outcome of livestock revolution. Rapid advances in genetic, reproductive technologies and feed improvement offer scope for overcoming many of the technological problems constraining increased production. The two different means to increase milk production are number driven and yield driven. It has been estimated for India that out of the projected demand of 137 MT of milk in 2020, 122 MT can be produced through demand driven growth while the rest 15 MT is to come through yield improvement (Dikshit and Birthal, 2010).

Several studies (Rao et al., 1995; Patil and Udo, 1997; Kurup, 2002; Dastagiri, 2003; Birthal and Rao, 2004; Bhowmik et al., 2006; Chandel and Malhotra, 2006; Samdup et al., 2010;

Dalal and Pathak, 2010; Udo et al., 2011) have reported crossbreeding as a superior technology both at household level to increase income earnings and at the state/country level to ensure higher productivity in the dairy subsector. In Gujarat, estimates of value added by cattle are 64 per cent higher in households with crossbreds compared to households with local cattle (400 vs 243 US \$). In Bhutan, crossbreeding has an even bigger influence on milk production and estimates of value added by cattle are 10 times higher in farms with crossbreds compared to farms with local cattle (1030 vs 107 US \$) (Udo et al., 2011). Rao et al. (1995) have reported that crossbreds generally come to first heat at an early age which ranges from 25 to 33 months compared to 38 to 41 months in indigenous cattle. They also have relatively longer lactation period than the nondescript cattle.³ Bhowmik et al. (2006) report from a study conducted in the state of Tripura that the adoption of new dairy technology, i.e. crossbred cattle in place of old dairy technology leads to higher per day milk yield. The shift in dairy technology brings about a percentage change of 161.84 in cross bred milk production over production from local cows.

The effect of crossbreeding programme in the country is not uniform. The Northern region accounts for about 40 per cent of all crossbred cattle in the country followed by the South (34 per cent), West (15 per cent) and the east (11 per cent). While Kerala has 52.3 per cent crossbred cattle in the total cattle population of the state, Rajasthan has the lowest share (1.0 per cent) among the Indian states. Uniform application of artificial insemination (AI) as a tool of genetic improvement across states may help in achieving partial success in near future (Dalal and Pathak, 2010). In spite of fairly large AI network, the system as a whole covers less than 20 per cent of adult female among cattle and less than 10 per cent of buffalo population (Dalal and Pathak, 2010). It indicates that there remains a long way to go for the country to enhance productivity. Again, some of the studies (Patil and Udo, 1997; Samdup et al., 2010; Udo et al., 2011) report that crossbreeding may lead to reduced cattle numbers and expansion of stall feeding practices which may contribute towards reduced grazing pressure on common property resources (CPR). Kurup (2002) has reported that the common property resources in India have shrunk by 30 per cent between 1950 and 1990. What little is left can no longer support any meaningful livestock production, as it is in an advanced state of degradation, with scanty biomass cover and little or no maintenance. Thus, the programme of crossbreeding has inherent win-win consequences with higher milk

productivity that leads to relatively higher income for the farmers and reduced pressure on grazing lands provided that these lands are on a continuous shrinkage.

Artificial Insemination (AI)⁴ is the most significant scientific invention for increasing animal productivity in the 20th century. This is still the only tool available to mankind for moving massive genetic payloads into populations and for rapidly re-engineering the desired changes in their genetic architecture (Kurup, 2002). Although more than 70 per cent of animals are bred using AI in the developed world, the technology is practically not available or available in quite limited extent in the developing countries (Kaaya et al., 2005). Rao et al. (1995) have observed that for almost a century, planners in the country have been trying to find answers to the questions: (I) is crossbreeding to be implemented on a mass scale and if so in which regions? (II) what should be the most optimum level of exotic inheritance? Kurup (2002) again remark that the crossbreeding policy prescribed by the government was scientifically and environmentally appropriate, but the application of the policy was mismanaged by almost all states except Kerala, parts of Gujarat and Andhra Pradesh. Thus, given that the breeding technology has significance in almost all the states to change the genetic makeup of the cattle stock towards improved breeds for higher productivity, there is a need to verify the AI network, the response of the farmers to the implementation of government AI service delivery programmes and the larger crossbreeding scenario in all the states. Again, given that demand for milk is increasing across the globe, production is low due to low productivity and there are constraints in the form of feed and fodder scarcity, adoption of a much more holistic approach to increase productivity is of urgent importance in the dairy sub-sector. Thus, the very first step in this backdrop can be to upgrade the genotype of the bovine stock through crossbreeding technology adoption and harness the stock with proper supply of feed resources, improved farm management and removal of the constraints hindering the adoption and continuation of crossbreeding technology.

The breed improvement programme is supported by feeding the animals a balanced diet commensurate with its genetic potential. Milch animals are usually fed one or two locally available concentrate feed ingredients, grasses and crop residues leading to an imbalanced ration- resulting in protein, energy, minerals and vitamins being either in excess or deficient (NDDDB, 2011). According to Dalal and Pathak (2010), balanced feeding plays a

predominant role in the production performance of dairy animals. They further argue that deficiency of adequate feed and fodder resources for livestock is considered endemic in India. It has been estimated that India is short of dry fodder by 31%, green fodder by 23% and concentrate feeds by 47%. With increasing mechanization of agriculture the availability of crop residues is on decline (Dalal and Pathak, 2010). Thus, in order to maintain the improved breeds of bovine stock and a higher milk production, adequate availability of feeds and fodder is of paramount importance. Due to competing pressure on land, ironically the shift in acreage from cereals to other crops and diversified use of agricultural residues, the gap between the demand and supply of fodder is increasing (Sharma, 2004).⁵ Dalal and Pathak (2010) points out that productivity improvement of dairy animals by increasing the supply of feed and fodder is beset with more of pessimism than optimism in the foreseeable future. The realized potential of milk production in Punjab's context is only 42.5 per cent in case of buffalo and 45.7 per cent in case of crossbred cows and is substantially affected by low quality and inadequate feeding of the bovines (Sidhu and Bhullar, 2004). Hence, feeding plays an important complementary role in increasing productivity of the crossbred cattle and buffalo population.

Dairying is an important component of mixed farming system in Assam. About 82% of rural households in Assam keep cattle or buffalo (ILRI, 2007; Kumar and Stall, 2010). Dairying in Assam is characterized mostly by rural smallholders' production using non-descript cattle and buffalo with pockets of specialized dairy production using improved dairy cattle in the peri-urban areas and in certain rural zones having better market access (Sarker, 2002). Kumar and Stall (2010) have observed that milk productivity in Assam is very low in relation to the cattle density. While the cattle density in the state (272 bovines with 259 cattle and 13 buffaloes per hundred hectares of cropped area) is more than double the national average, the per capita/day milk availability is almost one-fourth of the national milk availability.⁶ This clearly implies that productivity is very low in the state.⁷ Moreover, Kumar et al. (2007) also point out that crossbred cattle population is abysmally low in the state. Most of the available crossbred cattle are the upgraded breeds of Jersey and Holstein Friesian types in Assam (Paul and Chandel, 2010). According to the 19th Livestock census, 2012, crossbred cattle population constitutes only 3.84 per cent of the total cattle population in the state against the national average of 20.81 per cent. The average milk yield of

indigenous and crossbred cattle in the state is far below the national average. The Basic Animal Husbandry Statistics (2005) reports that the average productivity of non-descript cattle in milk in Assam is as low as 0.91 kg/day compared to 1.91 kg/day for the country as a whole. Again, the average productivity of crossbred cattle in milk in Assam is 4.38 kg/day against the national average of 6.50 kg/day for the country as a whole. Taking the case of the North East region as a whole the average productivity of crossbred cattle in milk in the region is 6.37 kg/day which is slightly lower than the national average of 6.44 kg/day. However, more than 90 per cent of cattle population is local breed with lesser productivity of 1.25 kg/day (Feroz et al., 2010).

Small scale dairy farming plays a vital role in the rural economy by increasing household income and has a great potential for improving the livelihood of the poor in the state (Mian et al., 2007). Given the right institutional incentives and market infrastructure, marginal and small landholders are capable of scaling up milk production and hence commercializing their dairy enterprise (Bardhan et al., 2012). Crossbreeding of indigenous animals with superior germplasm through AI in extensive manner will surely improve the livestock scenario of Assam. Access to improved technology and motivating the farmers to adopt it are the need of the hour (Sarker, 2002). Kumar and Staal (2010) are of the view that while increasing farm level production and productivity will require more improved animals, improved fodder/feed technology, access to livestock technology and livestock services, smallholder's access to reliable markets to absorb more milk at remunerative prices may remain a critical constraint in the state. However, as ILRI (2007) reported, only 66% of the total milk consumption in Assam comes from local market and the rest 34% is supplied by dairy products imported from outside the state. Hence, provided that market for locally produced milk exists, there is a need to prioritize productivity enhancement through breed improvement of the bovine stock of the state.

The poor productivity of Assam's bovine stock may be attributed to the absence of good breeds of cattle and buffalo coupled with acute shortage of concentrate feed and green fodder (Sarker, 2002). As Feroz et al. (2010) suggest, attention needs to be paid towards providing technical assistance in breed improvement, scientific management practices and feed and fodder availability which will lead to increase in milk production and productivity

in states like Assam in the North Eastern region. Given the poor employment potential of Assam's economy and a large chunk of the population reeling under abject poverty, laying a thrust to the dairy subsector may have a vital role in creation of livelihood opportunity and economic upliftment of major strata of the population. Further, there is a need to emphasize productivity growth through diffusion of high yielding bovine population in the state. The first organized attempt to improve the indigenous cattle stock for milk production in Assam was made during the 1st Five Year Plan with the introduction of Key Village Scheme (KVS) in 1953-54. Adoption of cross-breeding technology was encouraged through a number of subsequent programmes in the state, such as Intensive Cattle Development Project (ICDP), *Rastriya Krishi Vikash Yojana* (RKVY), Assam Rural Infrastructure and Agricultural Services project (ARIASP), National Project on Cattle and Buffalo Breeding (NPCBB) etc. However, in spite of these efforts, the proportion of crossbred cattle in total cattle population in the state is still abysmally low. According to the 19th livestock census of 2012, The proportion of crossbred cattle in Assam was only 3.84% against the national figure of 20.81%. This implies that there exists substantial gap in the penetration level of crossbreeding programme among the dairy farmers in the state indicating low rate of adoption of AI technology. It is against this backdrop that the present study intends to address the issue of low adoption of AI technology by the farmers of the state. This is done by identifying the factors that may affect adoption decision of farmers and extent of adoption of AI technology which might help in suggesting policy measures for addressing the factors that impede adoption of AI technology. Moreover, there is a lack of impact studies in the state highlighting the role of crossbreeding programme on welfare indicators such as income, employment, consumption etc. at farm household level. To fill this gap, the present study has been taken up to examine the impact of adoption of crossbreeding technology on three major outcome indicators, namely, income, employment and consumption of high value commodities in the state.

1.2. Statement of the Problem

Livestock is an important component of mixed farming system in an agriculture based state like Assam. Dairy cattle are reared by most of the rural households in the state. However, the cattle population of the state is low yielding indigenous type. It is also to note that the

state does not have any recognized indigenous breed which can be conserved. Livelihood of the vast segment of the farmers is thus constrained due to low dairy productivity which otherwise could have been improved through commercial dairying. However, empirical studies carried out across various parts of the world indicate that crossbreeding of the bovine stock through artificial insemination has emerged as economically viable technique to address low dairy productivity. Despite attempts to increase adoption of crossbreeding under various government schemes, the proportion of crossbred cattle in total cattle population in the state is abysmally low. According to the 19th livestock census of 2012, proportion of crossbred cattle population in the state is abysmally low compared to the national average. This implies that even though emphasis on crossbreeding programme was laid much before there is substantial gap in the penetration level of crossbreeding programme among the dairy farmers in the state. Available studies on adoption of agricultural technology point out that there are several socio-economic, environmental and perception factors influencing adoption and extent of adoption of agricultural technology at farm household level (Doss, 2006; Feder et al., 1985; Feder and Umali, 1993). Moreover, there can be various parameters relating to outcome of adoption of a new technology and measurement of these may demonstrate the superiority/inferiority of the new agricultural technology. The most prominent among these can be income, consumption and employment indicating farmers' wellbeing effect. It is to note that to our knowledge, there is a lack of studies on the crossbreeding of bovine stock in Assam to specifically set policy implications of pursuing and disseminating crossbreeding technology in the state. It is in this context, the present study has been undertaken to examine the impact and adoption determinants of crossbreeding technology and the related issues of productivity through cattle crossbreeding.

1.3. Objectives

The study has been undertaken with the following specific objectives:

1. To understand the dairy production and bovine population dynamics in the context of crossbreeding technology diffusion in the state.
2. To assess the impact indicators such as productivity, income, employment and consumption of high protein foods at the farmers' economy after adoption of crossbreeding technology.

3. To examine the determinants of crossbreeding technology adoption at farmers' level.
4. To understand the farmer's perception on the constraints to dairying with adoption of crossbreeding technology

1.4. Hypotheses

The following hypotheses have been pursued in the study:

H₁ : Adoption of crossbreeding technology enhances dairy productivity and production and other wellbeing indicators namely income, employment and consumption of protein-rich high value commodities of the adopter farmers.

H₂ : Adoption and extent of adoption of crossbreeding technology is influenced by various farm and farmer characteristics such as age, education, family size, herd size, land size, fodder cultivation, access to credit, grazing land and local breeding bull, membership of DCS, beneficiary of govt. dairy development programme, years of starting the dairy farm and number years since first knowing about AI; physical environment characteristics at which the farmers operate such as distance to market, all weather road and AI centre; and perception factor namely, farmers' self assessment of riskiness of going for AI.

1.5. Data and Methodology

The present study is based on the use of both primary and secondary data. Secondary data relating to the AI technology, bovine population and its composition (crossbred and non-descript), milk production and productivity, animal feed resource and veterinary service endowments etc in various states including Assam and the all India figures are collected from the publications of various organizations, viz. Assam Livestock Development Agency (ALDA), Khanapara, Assam; Directorate of Economics and Statistics, Govt. of Assam; Dairy Development Department, Govt. of Assam; Directorate of Animal Husbandry and Veterinary, Govt. of Assam; Directorate of Horticulture, Government of Assam; College of Veterinary Sciences (AAU), Khanapara, Guwahati; Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India; National Dairy Development Department (NDDB), Govt. of India; International Livestock Research

Institute (ILRI), North-East India office, Guwahati; National Dairy Research Institute (NDRI), Karnal, Haryana; Economic Survey of India, Government of India and published documents of National Sample Survey Organization (NSSO), India.

The study is based on primary data collected from dairy farmers spread over three districts of Assam namely Barpeta, Sonitpur and Karbi Anglong. Multi-stage sampling technique is used for selection of sample households. In the first stage, sample districts are selected following stratified random sampling method. Using secondary data on coverage of breedable cattle population, districts are grouped into high, medium and low strata depending on the density of crossbred cattle population per hundred hectares of geographical area. This is followed by selection of a district randomly from each group. Accordingly, three districts namely Barpeta, Sonitpur and Karbi Anglong are chosen from the high, medium and low strata respectively. In the second stage, two community development blocks (CDBs) are selected purposively from each district considering that one block has higher concentration of crossbred cattle with high artificial insemination (AI) coverage and the other with relatively lesser concentration and low AI coverage. The sample development blocks are selected in consultation with the senior officials of Assam Livestock Development Agency (ALDA), District Veterinary Officer and the Veterinary Doctor of Block Veterinary Dispensary. Before selecting the sample blocks the basic objective of the field study was clearly explained to these personnel. In the third stage 3 villages are selected from each development block. The selection of the villages are based on the understanding that both adopters of high yielding crossbred cattle and non-adopters are sufficiently present in each village. Adopters here are defined as those farmers who rear improved cattle breeds such as Jersey and/or Holstein Friesian (HF) crosses with local cattle while non-adopters are defined as those who rear only the local/nondescript cattle. Care was taken to see that villages in a block are not geographically contiguous to one another. In the last stage, sample farm households are selected in two groups: adopter and non-adopter of crossbred cattle. A total of 137 crossbred cattle adopters and 108 non-adopters (total 245) thus selected are interviewed for generating the primary data. The data are collected using a standard and systematically designed structured interview schedule covering various aspects relating to adoption and impact of cattle crossbreeding. The interview schedule is finalized after a few rounds of pilot surveys in each of the sample districts. The period of data collection is

December 2015 to March 2016 and the reference period for household information is 12 months preceding the survey (2014-15).

The data generated from the field survey are analyzed using appropriate statistical tools. The diffusion of AI, milk production and bovine population dynamics, general characteristics of the sample respondents etc. are analyzed using simple statistical tools such as ratios, mean, variance, percentage, etc. However, for more in-depth analysis, suitable econometric modeling and estimation is done as per requirement of the study. The impact estimates of crossbreeding technology adoption, more specifically the impact of adoption of crossbreeding technology on productivity, income, employment and consumption of high value and protein-rich commodities are obtained by using semi-parametric technique, namely propensity score matching (PSM) and *t*-test. For examining the determinants of crossbreeding technology adoption (artificial insemination), Cragg's (1971) Double-Hurdle or Two-Tiered model is employed. For identifying factors influencing adoption decisions, a Probit regression (first hurdle) is used and for identifying factors affecting extent of adoption of crossbreeding technology, truncated regression model (second hurdle) is applied in the Double-Hurdle model. The analytical techniques are discussed in detail in the respective chapters.

1.6. Layout of the dissertation

The dissertation is comprised of eight chapters including the introduction.

The second chapter includes a review of available literatures on the theoretical and empirical studies on the determinants of adoption of crossbreeding technology. Literatures on some broad agricultural technology adoption and impact ex-post the adoption of crossbreeding technology adoption have been discussed in the chapter. Summary of studies on feed and fodder availability, dairy farm management, and the constraints related to adoption of crossbreeding technology relevant to the present work have also been discussed in this chapter.

The status of bovine population and milk production dynamics in the context of diffusion of cattle crossbreeding in Assam is presented in the third chapter.

The fourth chapter presents the background of the field study area, sample, and broad sample profile and a preliminary analysis using descriptive statistics of the sample farmers.

The core of the dissertation begins with the fifth chapter that discusses the underlying issues of milk production and milk productivity such as economics of milk production with and without imputations of domestically available inputs and determinants of dairy farm profitability, lactation and reproductive characteristics of crossbred versus non-descript cattle, adoption of crossbreeding and labour use effect according to farm type, farm operations and issues related to marketing of milk.

The sixth chapter presents the average treatment impact analysis of crossbred cattle adoption on outcome indicators such as income, employment and consumption of high value commodities.

In chapter seven, the determinants of adoption and use intensity of crossbreeding technology, more specifically the artificial insemination (AI) technology have been discussed. It also highlights the constraints farmers perceive to inhibit their adoption of crossbreeding technology.

The concluding chapter of the dissertation presents the major finding of the dissertation, draws conclusions from the findings in the study and makes policy recommendations. The chapter also focuses on the major limitations of the study and scope for future research.

Notes:

1. A multivariate regression model was run to see the influencing factors of milk production. The regression coefficient of urbanization indicates that a one per cent increase in urbanization results in about 0.84 per cent increase in milk production and a one per cent increase in price of milk results in nearly 0.18 per cent increase in milk production. See Sharma (2004)

² The Gini coefficient for total household income is estimated at 0.8343 indicating that income distribution among different household levels is almost unequal in the total income, the share of crop income is the highest (85.29 per cent) followed by off farm (9.16 per cent) and dairy farm (5.08 per cent) income. It is observed that a 1 per cent increase in crop income will trigger total income inequality by 1.38 per cent with a caveat that other things are unchanged (Singh and Dutta, 2013).

3. The average dry period in indigenous cows is more than six months whereas it is less than four and a half months in crossbreds. (Rao et al. 1995)
4. The process of impregnating a female animal by an artificial method of putting male sperm inside her and not by sexual activity (Oxford Advanced Learners English Dictionary).
5. A shift in area from cereals to non-cereals/nonfood crops might result in adverse impact on milk production as farmers will have less crop residues to feed their cattle which is a major source of fodder for small holder milk producers. Sharma (2004) regressed milk production on area under cereals and found that one per cent increase in area under cereals increases milk production by nearly 0.30 per cent.
6. Bovine population pertains to the 18th livestock census of the Government of India and the figure of cropped area is from the estimates of 2008-09 (Economic Survey of Assam 2010-11).
7. Due to low productivity, Assam does not account for even 1 per cent of the total milk production in the country (0.62 per cent as on 2011-12) in spite of the State's share of 5.21 per cent of total cattle population in the country (18th Livestock census, 2007)

CHAPTER TWO

REVIEW OF LITERATURE

For conducting any research study, a clear knowledge on existing related works done on the topic of research undertaken becomes important. Considering that the dairy subsector has serious implications on income generation, supplementing nutrition to the masses and for the larger interest of employment generation and poverty eradication in countries like India, it is tried to study the subsector in the state of Assam with emphasis on its productivity issue. The productivity issue has been looked into through improved breeding technology adoption and impact assessment at farmer's level based on conducting a micro study in the state. To carry forward the study of the dairy subsector with respect to wellbeing impact and determinants of cattle crossbreeding in Assam, various published and unpublished sources are reviewed and cited underneath. The literatures reviewed have been arranged in five different subheadings: 2.1) crossbreeding technology and dairy productivity, 2.2) impact of crossbreeding technology, 2.3) feeds and fodder availability and crossbreeding technology, 2.4) dairy farm management and constraints; and 2.5) determinants of crossbreeding technology adoption.

2.1. Crossbreeding Technology and Dairy Productivity

Most important issue of the Indian dairy sector has been the poor productivity because of the low yielding indigenous cattle stock. In this context, improving the low productive cattle stock can be a viable strategy to increase milk productivity. In some of the studies (Birtal, 2002, Singh et al., 2007), crossbreeding of low-yielding indigenous breed with high yielding exotic breed has been widely acknowledged as an important strategy to improve animal productivity. In the Operation Flood Projects, crossbreeding has been accepted as one of the critical components of the strategy for achieving a rapid breakthrough in milk production in the country (Nair and Dhas, 1990). The operation flood project emphasized that for realizing higher dairy productivity genetic upgradation of local non-descript animals through crossbreeding with superior germ plasm should immediately be started. Dhaka et al. (2011) argued that the farmers should be encouraged to breed indigenous cows and buffaloes with

improved breeds through AI to improve productivity of the bovine resources. It has also been confirmed that there is higher return on investments in crossbreeding research and extension on cattle in India as with the adoption of crossbreeding, net social welfare has increased substantially (Kumar et al., 2003). National Commission on Agriculture (1976) reports that during 1970s it was widely realized that unless crossbreeding of indigenous cattle with exotic dairy breeds is undertaken in a big way, it will be impossible to bridge or even narrow the gap between the availability of and demand for milk in the country. The above discussion, thus, confirms the arguments on going for crossbreeding technology adoption for increasing the milk productivity of the cattle and buffalo population in the country.

Considering that the dairy subsector is an important component in an economy, it requires adequate attention for its improvement of performance. According to Chandel and Malhotra (2006), the performance of dairy farming system is estimated with respect to milk production and productivity, and adoption of crossbreeding technology. Kumar and Singh (2008) remark that crossbreeding of indigenous stock with the germ plasm of exotic animals is a well-known strategy for improving the productivity of indigenous cattle stock mainly of cattle, sheep, pigs and poultry. Again, crossbreeding of cattle and upgrading of buffalo have been the major thrust areas of the breeding policy; the rationale being that new breeds are more productive and their unit cost of milk production is lower than the local nondescript animals (Dhas, 2002). The technical programme for crossbreeding adopted by the government is to use non-descript cattle as the foundation stock and to impregnate them using semen from exotic breeds. This produces half-breeds with equal inheritance from the two widely different parents on contributing endurance and the higher productivity (Rukmani et al., 2007). Patil and Udo (1997) also advocate that the introduction of crossbred cows could be a suitable development option for farm households with little or no land, provided that these households have access to sufficient feed resources.

As low productivity has been a major problem of Indian dairying for a long time, one needs to recognize whether the problem of low productivity is due to inefficiency of the farm or due to lack of technology or input use. This may help in mobilizing properly the scarce capital and get better results within a short period of time (Saha and Jain, 2004). For this one

needs to enquire the number of crossbred cattle available as ratio of the total cattle population. The information on crossbred cattle population is made available for the first time through the Quinquennial Livestock Census conducted in 1982. This gives us the measurement of the crossbred cattle population in the country. The trend in the growth of the crossbred cattle population is very insignificant compared to the statistics of the same in developed countries (Kaaya et al., 2005). The economic benefits of crossbred cattle over the indigenous ones itself makes us to hypothesize that it is the lack of breeding technology or input use instead of inefficiency as an important driver of poor productivity of the Indian dairying. The economic benefits of crossbred cattle relative to indigenous or nondescript cattle are realized through its higher milk yield and longer lactation period (365 days in crossbreds compared to 300 days in indigenous breeds). Rao et al. (1995) observe that crossbreds come into first heat at an early age which ranges from 25 to 33 months compared to 38 to 41 months in indigenous cattle. The average dry period in indigenous cows is more than six months whereas; it is less than four-and-a-half months in crossbreds. Thus, conversion of the non-descript breeds into crossbred genotype becomes an effective technology for the productivity enhancement of Indian dairying at a macro perspective. According to Birthal and Rao (2004), there is considerable scope for productivity-led intensification with less pressure on natural resources given that the current productivity of Indian livestock is low. Future pursuance of crossbreeding policy for genetic enhancement of local cattle appears promising considering that yield increases and better breeding parameters in the crossbred cows are universally accepted facts even under farm conditions (Dalal and Pathak, 2010)

Dhas (2002) observes that although crossbreeding of indigenous breeds with high yielding exotic breeds of cows and Murrah buffalo can be carried out naturally or by AI, the latter is emphasized as economically viable strategy in all dairy development programmes in India. Again, AI is simple to conduct and even effective as breed improvement strategy of dairy cattle. Dhas (2002) further remarks that the progress in diffusion of breeding technology is reflected in the trends in number of AIs done in the state of Tamil Nadu. However, in Indian context both the number of AIs carried out and genetic evaluation of the bulls (semen quality) also becomes important. India has perhaps the world's largest AI network for the breeding of cattle and buffalo – over 30 thousand AI outlets in the government departments

and 10.5 thousand in the milk cooperatives (Dalal and Pathak 2010). The number of artificial insemination administered has increased significantly from nearly one million in the early 1970s to about 27 million in the late 1990s but the conception rates are still low (Sharma, 2004). The bulls are not genetically evaluated and thus, AI does not result in superior progeny generation after generation. Poor quality of AI results in poor conception. 85 per cent of the total 24.5 million AIs are conducted to generate crossbreds, but less than 20 per cent of them result in pregnancies and even fewer calves are born (Kurup, 2002). The performance of AI service also rests on the availability of door step visit of service providers. The notion emanates from the observation made by Kurup (2002) that the need to take the animals to the AI centre, services limits its reach and coverage and also causes severe stress to the animal. Stress being unfavourable to pregnancy, is one of the major causes for low conception rate due to AI in India (*ibid*).

Apart from the diffusion of AI services (both doorstep service delivery and in-centre service) quality semen production also holds importance. Sharma (2004) observes that the present production capacity of frozen semen doses is about 30 million against the estimated requirement of 65 million doses annually. Most of the livestock services like artificial insemination/natural service, vaccination, de-worming etc. are time-sensitive, which government institutions, at times, are not able to deliver due to financial as well as bureaucratic constraints. This necessitates the provision of efficient and effective decentralized services in tune with demands from the users.

Udo and Steenstra (2010) are of the view that the use of European dairy breeds or crossbreds is a major tradeoff between poverty alleviation through dairying and preservation of domestic animal diversity. For almost a century, planners have been trying to find answers for the questions: (a) whether crossbreeding is to be implemented on a mass scale and if so in which regions; (b) what type of *B taurus* breed is to be used and what should be the most optimum level of exotic inheritance (Rao et al, 1995)? The indiscriminate and continuous emphasis on crossbreeding with exotic breeds in the tracts of excellent indigenous breeds has led to gradual deterioration and near extinction of indigenous breeds (Sharma, 2004). Rao et al. (1995) have argued that crossbreeding has resulted in negative genetic development of the indigenous breeds. Animals with high exotic inheritance level demand

higher standards of management and feeding which are difficult to achieve in rural condition. Thus, maintenance of 50-75% crossbred inheritance is advocated as remedy (Dalal and Pathak, 2010). After thoroughly reviewing the cattle breeding policy the scientific panel on animal husbandry in 1965 recommended that bulk of the exotic inheritance should be obtained through jersey and crossbreeding with Brown Swiss and Holstein-Friesian should be tried on a limited scale (National Commission on Agriculture, 1976; Rao et al., 1995).

Thus, the choice of exotic breeds and the level of inheritance is an important issue along with the diffusion of breeding technology for the productivity enhancement of the dairy sector in India. Again, along with the diffusion of the technology, it is imperative to emphasize on maintenance of the high yielding crossbred cattle population which largely depends on availability of quality feeds and improved farm management practices in addition to adequate and proper animal health care service delivery. According to Chandel and Malhotra (2006), a major setback to the crossbreeding programme in some livestock systems can be attributed to the shortage of forage in meeting the dry matter (DM) requirement of crossbred animals. There is continuous change in feeding practices among the farmers. Dhas (2002) remarks that the change in feeding practices is complemented by change in cattle composition, i.e., adoption of crossbred cattle results to more stall feeding than grazing. The various literatures available on feeding the dairy animals and dairy farm management have been discussed in section 2.3 and 2.4 respectively with the larger interests of maintaining crossbred population to ensure enhanced milk productivity.

Isolated attempts to try AI in cattle have been made in India since 1939. However, planned and comprehensive studies on AI with special reference to the Indian condition were initiated in 1942 at Indian Veterinary Research Institute (IVRI), Izzatnagar, UP (National Commission on Agriculture, 1976). Crossbreeding of non-descript Indian cattle on field level was started only in 1964 with the launching of the Intensive Cattle Development Project (ICDP) by the Government of India. Various efforts laid on crossbreeding led to the development of a number of breeds such as *Sunandini*, *Karan Swiss*, *Karan Fries* and *Frieswal* with a higher milk production capacity (Kumar et al, 2003). In the strategy of livestock development, the first two Five Year Plans emphasized on the general utility

animals combining milk and drought qualities, and that this objective was to be met by primarily using some of the better Indian breeds to upgrade the non-descript milch and drought cattle (Singh, 1986), but from third five year plan onwards, the strategy was shifted to the breeding of high yielding crossbred cows whose male progeny would be less suited for rearing as work cattle (Nair and Dhas, 1990). In the fifth five year plan the unprecedented stress on animal husbandry and dairy sector was given based on several vital considerations. Firstly, while this sector has been receiving increasing attention in recent years, its contribution to the national income still remains notably limited. There lies enough potential for increasing such contribution. Secondly, it is visualized that, in coming years, there will be an increasing shift in demand from cereals to livestock products due to change in consumption pattern in both rural and urban areas. A much faster growth in supply will be necessary to meet such a demand. Finally, this sector is pre-eminently suited for improving the economy of the marginal farmers and agricultural labourers. This is because about 70 per cent of the rural households maintaining cattle fall under this category (Government of India, 1973). Recently, two policies that are giving utmost emphasis on cattle stock improvement through crossbreeding all across the country are National Project on Cattle and Buffalo Breeding (NPCBB) and National Programme for Bovine Breeding and Dairy Development (NPBBDD).

Although, as discussed above, breed improvement is vital for increasing the dairy productivity in Indian context and various programmes and policies were adopted for the same in the five year plans, dairy farm management and input use at adequate level in the form of feed resources significantly complement the breed improvement programme. Reddy and Subramanyam (2002) argues based on the findings in a research conducted to study the productivity gap of Indian dairying that rural farmers are not able to realize the potential of the crossbred cows and Murrah buffaloes. The annual yield of crossbred cow is 2,952 litres for farm bred animals and 1,234 litres in farmer-bred animals indicating a gap of 139 per cent. According to Reddy and Subramanyam (2002), as the breed of the animal is the same under both the situations (farm and farmer), management and increased input use (feeding) might have contributed to the higher milk yields in farmer-bred dairy animals.

Dairy animal provides food for household consumption, draught power and manure for agriculture and fuel for cooking. They utilize crop residues and by-products for their sustenance. Besides, they act as a store of wealth, as insurance in times of agricultural crisis, and as an instrument of socio-economic development, particularly for small holders and the landless labourers (Birthal and Rao, 2004). Alary et al. (2011) argue that although the contribution of livestock to farm income to reach the threshold of poverty appears to be modest, its contribution is nonetheless essential in reducing vulnerability and is vital for people as 60 per cent of households rely on the sale of animals to cope with food shortages or an urgent health problem in Office du Niger, Mali. Milk being played a prominent role in the food security issue of the people, the sector needs urgent thrust for its development. FAO (2013) reports that milk contains numerous nutrients and it makes a significant contribution to meeting the body's needs for calcium, magnesium, selenium, riboflavin, Vitamin B₁₂ and Pantothenic acid (Vitamin B₅). Milk and dairy products can add the much needed diversity to plant based diets and can contribute towards promoting child growth; it is frequently a vital component in specially formulated foods in therapeutic feeding of malnourished children. A detailed discussion on impact of crossbreeding technology adoption is presented in the next section (section 2.2).

2.2. Impact of Crossbreeding Technology

Dairying has highly favorable consequences on lives of the people in terms of income and employment generation, providing nutritional security, ensuring gender equity and so on. Dairy production and agriculture programmes are found to be more effective in improving nutrition if they are targeted to women with strategies to introduce small livestock and improved breeds of cattle and awareness-raising on the nutritional value of milk (FAO, 2013). FIAPPO (2010) reports that in 1999-2000, dairying including processing and selling of products, engages about 18 million people in India, i.e., 5.5 per cent of total workers and of the total workforce engaged in dairying activities, 92 per cent is concentrated in rural areas. Sidhu and Bhullar (2004) remarks in their study in Punjab that dairy is basically a labour intensive enterprise and uses surplus family labour and attached labour. The economic sustenance of small and marginal farmers of the state largely depends upon the incomes from dairy. For dairy production, farm level production costs at smallholder level are often

comparable with those of large scale enterprises, usually resulting from cost advantages emanating from the availability of low cost family labour (Dalal and Pathak, 2010). The Working Group on Animal Husbandry set up by Planning Commission for the XI five year plan states that gender equity is more pronounced in livestock sector, as women's participation is 71 per cent of the labour force while it is only 33 per cent in crop farming (FIAPO, 2010). Again, livestock constitutes a major source of animal protein for India's immense population as well as a key source of energy in agricultural production through its contribution in the form of drought power and dung (Doornbos and Nair, 1990). Being an important means of income and employment for smallholders and the landless households, livestock helps to alleviate poverty and smoothen income distribution in the process assuring balanced development of the rural economy (Arora et al., 2006). Singh and Kumar (2007) are of the opinion that dairying, which is the most important component of livestock sector, is identified as one of the most potential and viable occupation for landless and/or agricultural labourers, small and marginal farmers, and even to large farmers. Dairy business being complementary to agriculture, it has high prospect to enhance the level of living of the poorest of the poor particularly the landless labourers and marginal farmers through increased income (Mishra and Bardhan, 2009). The various inter-country experiences on the impact (both positive and negative) of dairying especially after adoption of crossbred technology have been discussed below.

The Impact of adoption of grade/crossbred animal explained from the study in Kenya by Nicholson et al. (1999) are that through the improved breeding technology it has higher milk sales, higher incomes, hiring more permanent labour, substantial changes to routine household activities and better health due to increased milk consumption by household members, especially by children. Nicholson et al. (1999) further observe that loss of animal due to disease is the most important of the risks mentioned by all adopting households, both before and after adoption of grade/crossbred cattle. The perceived risk of providing grade/crossbred cattle with enough feed increased after adoption, but the perceived risk of not being able to sell milk decreased with experience.

Melesse and Jemal (2013) conducted a study to assess the impact of dairy technology (crossbreeding) on the livelihood of dairy farmer households in Ada'a and Lume districts of

central Ethiopia and have found that dairying contributes about 62 per cent and 66 per cent of the total monthly income in Ada'a and Lume districts respectively. They are also found to save money from dairying in a traditional form of saving. Again, 77.5 per cent and 87.1 per cent of households in Ada'a and Lume districts respectively could consume more milk after adoption of crossbreeding technology. Dairy technology adoption has significant direct impact on livelihood indicators such as household income, food scarcity, health care and access to education and indirect impact through higher household expenditure on food, health and/or sanitation.

Patil and Udo (1997) report in their study carried out in Gujarat that crossbreds produce, on average, 1.8 times more milk than local *Desi*, *Gir* and *Kankrej* cows. Land is the major resource of mixed farms. An increase of one hectare in land area is estimated to boost farm income by 63 per cent and 35 per cent in households with and without crossbreds respectively.

Kluszczynska (2012) in his study in Ethiopia finds that crossbreeding improves food security and enables a transition from subsistence to small scale commercial farming. Crossbreeding has also been found with some negative impact that it leads to increased workload which might indicate overburdening of household members especially women and with larger feed consumption level of crossbred cattle, it may exacerbate the problem of feed scarcity.

According to Halakatti et al. (2007), adoption of dairy technology plays a crucial role. It helps not only to specify casual mechanisms and to evolve a technology of income generating behavior among the resource poor, but also enhances the efficiency and output of the interventions made in the development programme in India such as SGSY (*Swarnajayanti Grameen Swarojgar Yojana*).

El-Osta and Morehart (2002) in their study examines the impact of technology adoption on production performance and the findings shows that the adoption of a capital-intense (genetically superior milking cows and advanced milking parlours) or a management-intense (use of record keeping systems for total management, improved nutrition and feeding practices) technology would measurably lower the likelihood of a farmer being in the lowest

quartile of production performance. The factors that are found most important in positively influencing the likelihood of a farmer being in the top-performance group are specialization in dairy production and use of hired labour in addition to management-intensive technology.

Quddus (2012) finds that adoption of crossbreeding technology magnificently contributes to the improvement of the livelihoods of rural people. Higher level of technology adoption results in improved dairying with direct impact on higher milk yield, income generation, poverty alleviation and availability of animal protein.

Udo and Steenstra (2010) in their study on smallholder dairying in Indonesia remark that the main issue of intensification of small holder milk production is its contribution to household incomes. Smallholder dairying with European or crossbred stock increased household incomes. The introduction of dairying also creates job opportunities along with the dairy chain.

Samdup et al. (2010) have found that in Bhutan, dairy crossbreeding has contributed to the higher livestock gross margin in the intensive areas. Farmers in the intensive and semi-intensive areas find dairying attractive as a source of regular and reliable income compared to the traditional once-a-year return from crop production. Samdup et al. (2010) however said that the benefits of crossbreeding, in terms of milk production per cow, are reduced by poor survival and high reproductive wastage which should be addressed through integrated management intervention.

According to Patil (2006), crossbreeding can be an important development option for different types of farm systems. The use of crossbreds could imply a reduction in herd size which might also help in preventing degradation of forests and common grazing lands. Indeed primary data of some 270 herds in Gujarat indicate that in the last five years the average number of cattle and buffaloes has increased by 13 per cent, whereas the percentage of crossbred cattle in these herds has increased from about 6 per cent to 21 per cent.

FIAPO (2010) concludes in its study that since distribution of livestock is more equitable than land, growth in the livestock sector is deemed to be anti-poverty and equity-oriented. With the adoption of improved breeding technology income of the smallholders will rise and that will help in depressing poverty and inequality.

Sharma (2004) observes that the Government of India initiated major policy changes in the dairy sector during the late 1960s to achieve self-sufficiency in milk production. This policy initiative gave a boost to dairy development mostly through emphasizing on the adoption of the crossbred technology by the farmers and initiated the process of establishing the much needed linkages between rural producers and urban consumers.

Dalal and Pathak (2010) are of the view that if the effects of increased food grains availability and modern marketing (low cost access through cooperatives) are discounted off in India, it leads us to the supposition that available technology has played a very limited role in generating higher output growth even during the period of highest growth (4 per cent livestock product growth during 1980s). This raises doubts on the potential of available technology to contribute to productivity improvements in the future. Rao et al (1995) argue that the crossbreeding programme could not create the desired impact on dairy development because of various constraints such as lack of clear cut breeding policy, implementation of crossbreeding programme irrespective of its applicability/suitability to the area, lack of AI and veterinary aid facilities, repeat breeding etc.

2.3. Feeds and Fodder Availability and Crossbreeding Technology

There is enormous importance of good quality feeds and fodder availability to ensure productivity once the crossbreeding of indigenous breeds with exotic breeds takes the ride in a region. The crossbred and/or grade cattle needs more feeds than indigenous breeds. In Gujarat, crossbred cows were fed better than local cows: they received 1.4 times more concentrates, and about 1.2 times more green (weeds, forest grass, leaves and cultivated forages) and dry (straw and dried grass) feeds (Udo et al, 2011). The high yielding bovines especially crossbred milch animals and buffaloes, need enough cell-wall carbohydrate (fibre) to stay healthy and enough non-fibre carbohydrate (starch and sugar) to provide the glucose precursor needed for producing milk. Good quality green fodder or hay would provide the energy requirements. Oil cakes will provide necessary amino acids for the milk synthesis. It is, thus becomes highly essential to provide a balanced diet to dairy animals to exploit their genetic potential to the maximum extent (Rukmani et al, 2007). Regular and adequate supply of feeds and fodder will make crossbred cattle ready for higher milk yield.

There is variety of sources of feed and fodder supply. Livestock in India are fed largely on crop residues and byproducts and grazing lands. Although cultivated fodders and gathered grasses are two important sources of green fodder supply (kumar and singh, 2008), forages play an important role in the Indian context. According to Moran (2009), forages almost always provide a cheaper source of the key feed nutrients (energy and protein) than concentrate does; the lesser the purchased forages, lower is the feed costs. With well-planned dairy production systems, it should be possible to collect 95 to 100 per cent of the forages from on farm supply through strategies such as fodder conservation. Dikshit and Birthal (2010) reports that almost entire quantity of dry fodder (98 per cent) come from the cultivated crops, mainly from cereals as straws. Gathered dry fodder comprised only 2 per cent of the total. Again, 40 per cent of total green fodder consumed by livestock in India comes from grazing and the rest from cultivated fodder crops (27 per cent) and grasses, weeds and tree leaves gleaned and gathered from cultivated fields and uncultivated lands such as pasture, public lands, wastelands, fallows and forests (33 per cent). Rao and Hall (2003) opines that for the majority of smallholders, crop residues from dual purpose crops constitute 40-60 per cent of total dry matter intake and the rests are made up from homegrown feeds and grasses from common property resources. Rao and Hall (2003) are again of the view that crop residues are low in metabolized energy and crude protein. Efforts have been laid in India for supplementing the crop residues by high protein oil cakes; green fodder, and tree leaves. But the on farm adoption of it has been low due to improper fit of the technology in the farming system. Dalal and Pathak (2010) have observed that the area under green fodder crops is low; constituting no more than 5 per cent of the gross cropped area. Sluggish growth in area under fodder crops in most parts of the country except in the irrigated regions is a reflection of the rising competition between food and fodder crops for limited land and other resources. However, of the technologies developed to improve the nutritive value of crop residues, more attention has been given to chemical treatment of cereal straws than to supplementation. In a study in Ajmer and Bikaner in Rajasthan, Suresh et al. (2010) have observed that the quantitative and qualitative decline in the pastureland has affected the herd size and its economic performance adversely. Farmers, in the study, report that the decline in pastureland is 75 per cent in both the districts. The decline is 90 per cent in semi-arid zone and 60 per cent in the arid zone. In a study by Udo et al. (2011) in

Kenya, observes that with human population densities continuing to rise and landholding shrinking in Kenyan highlands, it has become inevitable that the number of free grazing farms will continue to decrease. Kumar and Singh (2008) have stressed on the need to create concerted efforts to arrest deterioration of common property resources through legal, social and institutional means. Suresh et al. (2010) further comment that encroachment by the private parties is the most important reason for reduction in pastureland and called for participatory pasture management with beneficiary contribution is considered as an appropriate step to conserve the pasture and augment productivity.

According to Dalal and Pathak (2010), a marked shift in favour of concentrate feeding has been observed in the country since the 1980s. The shift towards the use of cereals for feed has substantially increased in developing countries since the 1980s though it actually declined in developed countries. According to Devendra and Sevilla (2002), “there is a significant potential for more effective use of locally-produced agro industrial by-products (AIBPs) and non-conventional feed resources, all of which are under-utilized currently”. Rao and Hall (2003) remark that owing to cash constraints small holder farmers in the drier, semi-arid regions generally do not purchase compound and agro industrial by-products in the market. In the dry months, particularly the 2-3 months prior to the onset of next monsoons, they face considerable feed shortages that adversely affect animal productivity. Sharma (2004) has observed that production of certified seeds of high yielding varieties of fodder crops and pasture grasses/legumes has been a major focus area since the early 1950s but with a limited success. Again, animal feed production is mainly concentrated in the private sector; cooperatives also manufacture and supply feed to the farmers. But the quality control measures for animal feed are not very effective. So there has always been an issue of poor quality of feeds.

The production and marketing context and the household resource endowment context are also important in conditioning farmer’s fodder practices and preferences. There is particularly strong market for fodder from urban-based dairy production systems. Rao and Hall (2003) prescribed that a shift in breeding strategy towards the development of dual purpose plant types could increase the adoption of improved varieties. Such an approach

offers opportunities to improve the nutritive value of crop residues and could potentially lead to improvements in the productivity of animal production system.

2.4. Dairy Farm Management and Constraints

The thinking and attitude of the farming community have changed during the recent period from traditional to more forward looking and they have started exploring the possibilities of increasing their earnings through other means and livestock especially dairy being one among them (Sidhu and Bhullar, 2004). However, to realize increased income in the dairy sector necessitates improved dairy farm management. Dairy farm management directly relates to dairy farm performance. The adoption of improved cattle calls for improved farm management that depends on efficient input use in the form of feed and fodder, health care services, vaccination and infrastructures such as cattle sheds in favorable conditions. Farmers' knowledge and awareness play a crucial role in the effective management of the farm. Again, herd size in the farm is an important element in the dairy farm management. In India, the average herd size is about two milking animals and average daily milk production per herd is about four litres (FIAPO, 2010). Kaaya et al. (2005) advocated for smaller herd sizes of 14 heads on average in Uganda in the context of AI use because use of AI requires a higher level of management input in aspects like feeding, routine cattle/herd observation, and communication with the AI technicians. It appears that as herd size is increased the farmers' capacity to manage and pay for AI services is constrained. Poor heifer management is a major problem in many (if not most) Asian smallholder dairy farms. Young stock receives insufficient attention because they do not generate income for several months together (Moran, 2009). It is generally the lactating animals that get priority from feeding and health care point of view. Kumar et al. (2013) have found that co-operatives have a positive impact on the herd size and its quality, milk production, productivity and profitability. It also has a positive impact on the adoption of the milk safety measures with reduction in additional cost of compliance. Co-operatives are conceived as the main vehicle for implementing dairy development programmes in the country, and much of the success of the 'White Revolution' in India is attributed to the co-operative framework of the dairy development strategies. According to Moran (2009), "the number of cows milking as a per cent of the total cow herd is influenced by, most importantly among several factors, the

lactation length, inter-calving interval and calving rate. Longer lactation length, higher calving rate and shorter inter calving interval affects milk productivity positively". The grade or crossbred cattle being superior to the non-descript cattle, efforts for improved dairy farm management should be given more for crossbred or grade cattle. Nicholson et al. (1999) state that ownership of grade or crossbred animal is a key element in the development of intensive dairy production. Bardhan et al. (2012) based on their studies in the state of Uttarakhand, India have prescribed two sets of policy interventions that are likely to compliment in improved farm management: a) It is necessary to enhance collaboration between extension service providers and farmers which may enable uptake of improved dairy technologies and resultantly enhance scale of milk production; b) it is required to invest in physical infrastructure like roads, storage and milk processing facilities. It is necessary not only because milk is a highly perishable commodity but also to tap the commercialization potential of excess amount of milk retained by households. According to Quddus (2012), the major constraints for dairy technology adoption have been considered to be as a) ill equipped and negligible services at AI centre, b) no provision for testing of animals; c) poor knowledge of farmers about health care of animals and inadequate knowledge about proper feeding and balanced ration. Thus, various external factors are found to affect dairy farm management which indirectly has bearing on milk productivity.

Rising demand for milk gives way for increased production by the smallholders. FAO (2013) reported that increasing demand and relatively higher prices for milk and dairy products also provide an opportunity for the millions of smallholder farmers who produce milk in developing countries to increase their livelihoods. Based upon the smallholder farmers' efficiency in the realization of higher milk productivity, Dastagiri (2003) has forecasted through polynomial price lag model that during 2000-2020, Indian domestic supply of milk will grow at the rate of 5.56 per cent reaching the level of 232.09 million litres in 2020 from 76.56 million litres during 2000, while consumption (demand) will grow at the rate of 4.77 per cent during the reference period giving a surplus domestic production of 84.88 million litres. Moran (2009) is of the view that small holder dairy farmers with their knowledge on cost of production allow them to determine their profit margins and this is crucial to operating a sustainable dairy enterprise. According to Udo and Steenstra (2010), smallholder dairying is also competitive with large-scale dairy farms, as it uses family

labour and has no high requirements for investment. Farmers with sufficient household labour, do not consider the use of family labour as a production cost, because alternative employment opportunities are limited. The market for milk is the major pull factor for smallholder dairying, and in countries such as India, Bhutan, and Kenya, it produces the majority of the total milk production of the country (Udo and Steenstra, 2010). Bardhan et al. (2012) have identified that milk production, distance to market and extension contact as the important policy variables which influence producers' market participation and also choice of agencies for sale. Profitability is a major impetus point to adopt improved farm management at farmers' level. As the growth in dairy sector is influenced by farm profitability, Sidhu and Bhullar (2004) cites various farm profitability determining factors such as expansion of milk processing and collection facilities at the doorstep of the farmers, easy availability of credit for dairy sector, increase in the demand for milk and milk products and remunerative prices in their study to assess the impact of livestock on income and employment in the state of Punjab, India. As the demand for milk is important determinant for farm profitability and resultantly the improved farm management, persistency of higher demand for milk and milk product is important. The economic crisis of 2008 slowed down the rising trend in demand, but it is expected that the growth in consumption of animal products in emerging and developing countries like India will remain strong (Udo et al., 2011).

In India, inability of small holder producers to access market is one of the major limitations in harnessing opportunities in livestock production. Nearly 45 per cent of the milk produced in the country is retained in villages by the rural households and the remaining 55 percent is marketed (Bardhan et al., 2012). The much hyped co-operative dairy development in India has not been able to significantly affect the dominance of the traditional marketing channels. Again, the functioning of the traditional milk market and its potential in income and employment generation has not been conceived properly in India (Kumar et al., 2010). Players in traditional milk marketing system include village and urban consumers, local sweet shops, restaurants and hotels and milk vendors or middleman. These markets are unstable and often exploitative, particularly during the flush production season.

Thys et al. (2005) have remarked in a study to assess the socio economic determinants of urban household livestock keeping in semi-arid Western Africa that main identified constraints for urban livestock production are animal health problems, feed supply, and theft and manure management. Udo et al. (2011) in their study cited that farmers ranked scarcity of good quality feeds as the most important constraint followed by lack of labour, poor animal performance and lack of cash to purchase inputs. There are studies that identify repeat breeding¹ as an important constraint among the various attributes of farm management. The apparent fertility problem in crossbred bulls seriously hampers their selection. The rejection rate among crossbred bulls is as high as 40 per cent and there is no research to mitigate the problem. Again over 30 per cent of the adult female cattle are not fit for breeding (Kurup, 2002).

According to Rathore et al. (2009 b), in the adoption of recommended cattle rearing practices, the cattle keepers have to face several problems of breeding, feeding, housing, milking, calf rearing and health care management along with policy and organizational constraints, financial, technical and social problems, as a result of which an adoption gap gets created

According to Dhaka et al. (2011) the dairy productivity is constrained by several factors including inadequate knowledge, inadequate availability and poor quality of feed and fodder, poor genetic potential of animals, high incidence of diseases, repeat breeding, long calving interval, non-availability of support services in time and poor extension support etc which come out to be as the major limiting factor to dairy production.

Iype et al. (1993) in their study find that milk yield was higher for cows in larger herd, i.e., for the group of 10 and above which has the implication that when more number of animals are kept for milk production the owners are more conscious about economic production and profit. They retain better animals and provided relatively better farm management. In other words less than 10 cattle heads is a constraining factor towards higher milk production and farm profitability.

Aulakh et al (2010) report based on their study carried out in Punjab by interviewing 180 dairy farmers that the high cost of raw material for construction of buffalo shed is responded

by 84.26 per cent followed by 76.1 per cent of the farmers agree on the constraint of less market price of milk and the lack of knowledge regarding recommended management practices (agreed by 70.56 per cent farmers)

In a study by Keshava and Mandape (2001) done in Muzaffarpur district of North Bihar, it is reported that 87 per cent respondents reveal the problem of unavailability of veterinary facilities in need followed by disease prone animals, costly cattle feed and unavailability of regular milk market reported by 64, 55, and 51 per cent respondents respectively.

The decomposition of the gain in milk yield in the farm bred crossbred animal over farmer-bred in to its causative factors indicate that 20.26 per cent of total change is contributed by better management of crossbred cows and 32.61 per cent of change in milk yield is caused by increased input use (Reddy and Subramanyam, 2002).

Inadequate supply of AI equipment and preservation facilities of semen, inadequate training of veterinarians in evaluation of semen quality, inadequate follow-up of cases in which AI has been done, failure of the farmers to get treatment for reproductive disorders in time and to arrange pregnancy diagnosis within 2 to 3 months of AI, fixation of AI targets for field staff without considering the breeding season and the problem of providing AI facilities at farmer's door step are the some of the other impediments in administering the AI (Sharma and Sohal, 1989).

Arora et al. (2006), based on their study in the US Nagar district of Uttaranchal, remark that technologies developed in the recent past in the field of animal husbandry sector have not been successful in changing the socio-economic conditions of the rural poor to the extent that was originally envisaged and for this failure it may be attributed to the lack of thorough understanding of the level of knowledge of the farmers and the factors influencing the adoption of improved technologies by the farmers.

Agarwal et al. (2007) carried out their study in three states of India, namely Punjab, Karnataka and West Bengal based on cross section data of 225 adopters of crossbreeding technology find that among the breeding constraints majority of adopters of crossbreeding technology in Punjab report lack of progeny tested bulls, low fat content in crossbred cow milk, high mortality in crossbred male calves and repeat breeding as serious constraint. In

west Bengal, almost all the constraints are of serious type except lack of progeny tested bulls.

The major constraints in adoption of breeding practices are poor conception rate; repeat breeding and inefficient treatment of repeat breeding followed by inadequate knowledge of AI, lack of pedigree bull for natural services and AI centre (Singh and Chauhan, 2006).

Rathore et al. (2009 a) conducted a study in Rajasthan by interviewing 400 cattle keepers and found that lack of AI centres, distant location of veterinary hospitals, poor conception coupled with repeat breeding, lack of pregnancy diagnosis (PD) facilities and costly treatment are the important and very serious constraints in adoption of recommended breeding practices.

Gupta and De (1989) observes certain technical constraints regarding rearing of crossbred cattle in their study conducted in Jaipur district of Rajasthan and ranked them in a descending order of severity such as a) crossbred cows cannot tolerate high temperature during summer, b) crossbred cows require relatively more care in rearing, c) crossbred male cows are not suitable for drought purpose, d) feed and fodder requirement of crossbred cows are relatively higher than the local cows and e) finally, crossbred cows are more susceptible to diseases.

Yadav et al. (2008) identify some of the important constraints in adoption of artificial insemination (AI). They are less success rate of AI, less knowledge for detection of silent heat, importance and timing of AI, lack of proper AI facility, difficulty in disposal of crossbred male calves, many animals not coming to heat in time and high cost of AI etc.

Lack of awareness about hay and silage preparation and treatment of poor quality roughages, high cost of fodder and concentrate, lack of knowledge about balanced feeding and scarcity of green fodder are the main constraints which restrict the balanced feeding of animals (Rathore et al., 2009 b)

Singh and Chauhan (2006), based on their study in Tonk and Jhunjunu district of Rajasthan state, remark that the main constraints have been the high cost on feeds and fodder and limited availability of resources for raising fodder crops. Other constraints under feeding of

animals are the poor availability and high cost of compound feed, mineral mixture and fodder seeds related to limited financial resources.

Non-remunerative price of milk, non availability of good dairy animals, high cost of concentrate and dairy animals, non availability of green fodder, irregular payment for milk by procuring agencies are the most commonly felt problems and rated them as severe (Reddy et al, 2003).

In a study conducted by Ghosh and Chand (2001) in Birbhum district of West Bengal report that poor conception rate of AI and non availability of veterinary medicines in the animal Health Care is the most severe constraint faced by small farmers followed by lack of knowledge about recommended feeding practices and too much repeat breeding through AI as important constraint in adoption of improved dairy farming practices. Again, constraints expressed by the dairy farmers are favourable attitude towards growing grain and other crops rather than growing fodder crops, followed by prejudice against the drought capacity of crossbred male, and a favourable attitude towards natural services compared to AI as the important constraints which are categorized as socio-psychological constraints by Ghosh and Chand (2001) hindering the adoption of improved dairy farming practices.

According to Kumar et al. (2009 a), based upon their study in the operational area of Krishi Vigyan Kendra, Banka of Rajendra Agricultural University, Bihar, the severe constraints relating to breeding practices are non-functioning of AI centre followed by poor conception rate and ineffective treatment. Inadequate knowledge of AI is the next important constraint followed by lack of good breedable bulls for natural services and scarcity of resources to maintain crossbred/superior breed of milch animal. Kumar et al. (2009 a) further report that the severe constraints relating to feeding practices have been the preference among farmers to grow food crops/cash crops instead of fodder crops, followed by inadequate knowledge about improved feeding practices of dairy animals whereas high cost of ingredients of concentrate mixture also hurdles in the adoption of improved dairy farming practices. Other constraints have been the under-feeding due to limited financial resources, inadequate resources for cultivation of fodder crops throughout the year, poor availability, and high cost of compound feed and mineral mixture and lack of grazing facilities.

The study has found that higher value of milk output may not be due to the technological improvement alone because the increased use of inputs have also played role on the milk output¹ and this necessitates decomposing of the total value of milk output into its causative factors (Kumar, 2001).

Based on the study carried out by Kumar et al. (2009 b) in Jhansi district of Uttar Pradesh it is reported that non-availability of green fodder round the year faced by almost 81 per cent respondents is a severe problem relating to feeding constraints. Again, 36.7 per cent respondents face the problem of non availability of land for fodder cultivation as a severe problem.

2.5. Determinants of Crossbreeding Technology Adoption

Feder et al. (1985) have reported that the factors influencing adoption of agricultural technology often focus on household resource endowments, characteristics of the household head, location of the household, the nature and extent of information provided before adoption, and the characteristics of the technology. Apart from these factors, institutional factors are also responsible for the adoption of dairy technology where various programmes and policies formulated influence the adoption. Based on studies carried out across countries on factors related to farm, farmer and the technology itself in the adoption of the dairy technology and institutional set up prevailing in India a general discussion on the factors influencing dairy technology adoption is carried forward. As discussed in section 2.1, AI is an economically viable technology to change the genetic makeup of the cattle population, farmers also prefer to have purebreed grade cattle such as jersey and/or Holstein Friesian as an important strategy to increase milk productivity. In the present review of existing literature on adoption of dairy technology, grade cattle adoption and pursuance of AI have been clubbed together as dairy technology as both have the similar objective of productivity enhancement.

Kumar et al. (2013), on the basis of a cross comparison between member and non-member farmers of the dairy cooperatives, suggest that the scale of farming and level of adoption of improved animals have been significantly higher for the member farmers. Similarly, the co-operative member households contribute significantly higher quantity of milk at higher levels of productivity than the non-member counterpart. Co-operatives enhance vertical

integration of dairy market and also facilitate delivery of inputs (feed, AI etc.) and veterinary care services to the participants.

Important conditions influencing the successful implementation of crossbreeding include an increased demand for cow milk or young stock resulting in a remunerative market, low demand for draught animals, and accessibility of veterinary assistance to farmers and low prices of high quality feeds relative to milk prices (Rao et al, 1995).

According to BIRTHAL and RAO (2004), human population density, agro climates, technology and size of landholdings appear to be the major determinants of livestock intensification and so also urbanization with rising demand for animal foods. BIRTHAL and RAO (2004) further opine, “since livestock intensification² is significantly associated with small landholders, the process may, however, come under stress due to their poor resource position”. Thus, to keep the process of intensification going, smallholder livestock production needs policy support in terms of credit, insurance, technology extension, markets, etc.

MUGISHA et al. (2014), in their study in Uganda, explain that better organisation of the informal sector and strengthening of the formal sector in addition to other critical inputs like feeds and water as incentives contribute significantly in the adoption of AI as an important cattle breeding technology. The size of grazing land (smaller holder), practice of record keeping, preference for AI, availability of milk markets as well as access to extension services are key factors determining the adoption of AI services. The reasons for why AI service is not preferred by the majority (63.6 per cent respondents) are that bull/natural service available as the main service; notion of AI purported to produce more bull calves than females, lack of money to pay for AI when the animals are on heat, distance to AI centre and the perception that they are expensive, lack of sensitization about the benefits of AI, very high expectations of AI which remain unmet, higher chances of dystocia in cases where AI was used coupled with limited number of veterinary practitioners to attend and the problem of repeat breeding with charges each time relative to natural service (only one charge even in repeats).

NICHOLSON et al. (1999) examine the factors associated with adoption of three dairy-related technologies and practices in coastal province, Kenya: Grade or crossbred dairy cows,

Napier grass production and the infection and treatment method for protection of cattle against East-Coast fever. Nicholson et al., (1999) find that the reasons for non-adoption of grade/crossbred cattle are lack of money to purchase the animal coupled with their inability to participate in a development project and lack of credit. The other factors being 'children need schooling' (income factor), 'insufficient land (access to resources) and disease risk (risk factor)

Baltenweck and Staal (2000) in their study in Kenyan highlands, have found that the access to credit, land size, quality of livestock delivery services, education level and price of milk (farmers' responsiveness to better market conditions) positively affect the crossbred cattle technology adoption³ decision, while time of establishment of the farm and age of household head affects negatively. In case of smallholders, poor credit accessibility and bad road infrastructure delays adoption of crossbred cattle technology in Kenya. During the post liberalization of dairy industry (post 1992); the speed of adoption has slowed down suggesting that the conditions for adoption have worsened with the closing of some dairy cooperatives and privatization of livestock services. The study suggests that liberalization policies may need to be accompanied by interim support for farm services and market mechanisms to maintain technology adoption trends.

In areas where there is strong market linkage, efficient provision of veterinary healthcare and AI services at farmers' door step and supply of adequate feeds influence positively the adoption of crossbreeding technology in Ethiopia (Kluszczyńska 2012).

Quddus (2012) based on a study conducted in three agro ecological zones of Bangladesh interviewing 180 dairy cattle farmers finds that about 17.5 per cent rural farmers and 70 per cent semi-urban farmers rear crossbred cows. The secondary and higher educated farmers are 9.7 times more likely to adopt improved technologies compared to illiterate farmers. Quddus (2012) suggests that knowledge about crossbreeding technology through training, availability of reliable and continuous technical assistance, availability and low price of concentrate feeds, increased and timely provision of medicines, increasing AI facilities, providing pure breed and strengthening the extension services stimulates the AI adoption.

Halakatti et al. (2007) conduct a study to understand dairy farming technology adoption behavior of Swarnajayanti Gram SwarajgarYojana (SGSY) participating rural women in Haveri district of Karnataka. They find that the adoption behavior of milch cattle beneficiaries and SGSY is an outcome of interplay between the adoption with socio-economic (education, social participation and economic motivation), information source utilization (ability to select response to the innovations already detected from the relational analysis as personnel locality and personal cosmopolitaness), project operational intervention (perception about milk marketing channels, veterinary health care, feed and fodder incentive and extension support) and cognitive orientation (knowledge, attitude and profit awareness) factors.

El-Osta and Morehart (2002) advocate for widening access to relatively inexpensive credit which may provide producers with the means for investing in genetically superior milking cows, allowing for a fuller use of their managerial ability and for higher levels of milk output.

Howley et al. (2012) have categorized the factors that influence the adoption of AI into farmer's personal characteristics and structural farm factors. Age of the farmers (-), off-farm job (-) and farmers with children (+) fall under farmer's personal characteristics, whereas, the structural farm factors are gross margin per livestock unit (+), farm size (-), advisory services (+) and costs on AI (-) are found to influence the adoption of AI technology in Ireland.

According to Batz et al. (1999), the characteristics of the technology itself are also important to influence farmers' technology adoption and usage decisions. In particular, the relative complexity, risk and investment characteristics of technologies significantly affect their adoption and diffusion.

Tefera et al. (2014), based on a study conducted in Bilbilo district in Ethiopia, examine the various factors on the probability and extent of AI adoption among dairy farmers and found that contacts with extension agents, access to credit, income from milk sales, feeding concentrates to cows and family size influenced the probability of adoption positively (except family size). Education level of household head whereas had positive impact on the

extent of AI use without affecting the probability of adoption. Tefera et al. (2014) further point out that it is more preferred for farmers to use crossbred bulls due to distance and the risk associated with the efficiency of AI services. However, longer the experience with crossbred bulls, the less is the AI used.

Kaaya et al. (2005) in their study in three districts in Uganda namely, Mukono, Kayunga and Wikiso based on cross section data collected from a total of 180 randomly selected households, find that adoption and use of AI technology is influenced by farmer characteristics (such as age of farmer, time of involvement in dairying, household member size, years of knowing AI technology, weekly hours on cattle herd) farm related attributes (farm land size, cattle herd size, annual extension visits, milk sold per month, cattle herd born using AI) and attributes related to the technology itself (AI technicians known, distance from farm to AI technicians and per AI service cost at farm and farm per bull service cost)

Crossbreeding technology adoption is also stimulated by certain institutional factors. In Bhutan, crossbreeding for dairying is stimulated by the 1985 breeding policy which promoted crossbreeding with Brown Swiss in the high altitude areas and with Jersey in areas with relatively good market access and using local breeds in remote areas that have harsh environmental conditions (Udo et al., 2011).

Yohannes et al. (1993) report that among social variables, education, experience, production knowledge and awareness and technical variables like productivity of cows, veterinary services and availability of land to grow feed on grazing area significantly influence adoption of crossbred cattle.

FAO (2005) observe that the productive potential of animals depend crucially on the quality of animal health system and in this respect, India has a poor record. Although, the country has emerged as the largest milk producer in the world, the quality of livestock support services remains poor. There is need for creating a level playing field for private practitioners in high potential areas with relatively good access to markets. In the long term, with the development of livestock services sector and service delivery becoming more commercial and self-sustainable, the government ought to dedicate itself towards public

good provision such as disease surveillance, disease prevention and food hygiene, zoonosis control, sanitary control, compliance monitoring, market regulation and so on.

Baltenweck and Staal (2000) have identified three main routes towards adoption of improved dairy cattle in Kenya, namely upgrading the existing local animals; getting the dairy animals at no cash, costs or purchasing them, each route having drawbacks. The first route enables a farmer to dramatically reduce the lumpiness of the entry cost, as the costs of raising the heifer are spread out over several years and has significant risk of losing the animal in that period. Second route is either as gift from parents, relatives or through projects. Here entry is free but it may set conditions on the farmers which become difficult to assess. Finally, third route is the purchase of improved dairy breed where costs may be high compared to monthly wage and/or savings from off farm activities. Finally, the obvious way to finance is credit but field work shows that access to credit by smallholders is limited in Kenya (high entry costs and production risks).

Dairying in India being largely a smallholder phenomenon is characterized by low productivity (Mishra and Bardhan, 2009). So that the productivity can be improved of this sector, there has been continuous emphasis at the recent period on the technological intervention in the sector. There are theoretical and empirical studies that have dealt with several issues underlying the adoption of the technology in dairy sector. Some important studies so far carried out have been discussed below that are on the factors and pattern of adoption of breeding technology in dairy sector.

In a study conducted in Haryana on pattern of innovation adoption, Singh and Kumar (2007) observe that all individuals in a social system do not adopt an innovation at the same time, rather they adopt in an ordered time sequence. The study concludes that majority of the early adopters had high level of innovativeness in accepting artificial insemination for their dairy animals, whereas, a large number of early majority dairy farmers had only medium level of innovativeness in accepting artificial insemination for their dairy animals.

Mishra and Bardhan (2009) in a study undertaken in five selected villages of Rudrapur block, US Nagar district of Uttarakhand assess the influence of factors on adoption and non-adoption of crossbreeding technology and early versus late adoption of crossbreeding

technology. The study shows that probability of early adoption of crossbred animals decreased when head or farm owner is the farm decision maker, implying that extension approach which is more family oriented rather than exclusively targeting the head of household, may favourably affect early adoption, along with factor such as membership in a farmer's group. Other factors such as distance to market affects early adoption with a negative relationship (higher the distance, lower is the adoption), and access to credit and information with positive relationship.

Adoption of technology is multidimensional and a wide range of factors such as attitude, beliefs, perceptions, personnel characteristics and many others may affect it (Rezaei and Bagheri, 2011). Rezaei and Bagheri (2011) further report based on results of logistic regression that need to artificial insemination is directly associated with the adoption of it. In other words, the more technology is adjusted to dairy farmer's needs the more they will adopt it.

According to Arora et al. (2006), level of education, milk production and consumption, mass media exposure and extension contact have positive and significant correlation with adoption of improved animal husbandry practices.

Information supplied by formal and informal sources is inadequate in creating awareness about AI and needs to be sharpened. Well conceived efforts should be made to diffuse the relative gains accruing from the use of AI at the evaluation stage, which could cause a considerable reduction in the rejection of AI (Sasidhar et al., 2004). Sasidhar et al., (2004) based on reviewing the literature point out that most of the dairy farmers possess medium level of knowledge in AI and the members of the milk cooperative societies are having more knowledge on AI than non members. Households seek AI only when it is available with little difficulty. In areas where they may need to travel long distances for obtaining AI, they prefer to choose natural service which is normally available within the village (main reason for failure of AI at the village level)

Yadav and Jain (1984) have found in their study based on correlation coefficient between adoption of crossbred cattle and various socio-economic factors that factors such as size of

land holding, age of the cultivators, education of the cultivators and economic status of the cultivators are positive and significant in adoption of hybrid cattle

According to Tyagi and Sohal (1984) occupation, economic motivation, price of milk and knowledge of the technology are significantly related to adoption of dairy innovation. Farm size also affects the adoption of dairy innovation but with a negative relationship, indicating that as farm size increases, the adoption level of dairy innovation decreases.

Singh et al. (1979) in their study indicate that non-adoption of AI service is due to the poor knowledge level about AI, negative attitude towards it, unscientific values associated with it and unreasonably poor opinion on the outcome of artificial insemination. Singh et al. (1979) strongly advocate for playing role by the extension agency to carry out effective educational programme which may greatly accelerate the pace of adoption of AI by the dairy farmers.

2.6. Summing Up

Dairy being an important sector to ensure nutritional security and providing livelihood opportunity to the masses, improving the performance of the sector through crossbreeding has been the important policy strategy in the recent period. The technical programme of crossbreeding adopted by the government is to use non-descript cattle as the foundation stock and to impregnate them using semen from exotic breeds. AI is the most commonly used and economically viable measure in the crossbreeding programme but literatures suggest that the performance of AI largely depends on the proper diffusion of AI (e.g., door step visit of service providers) and genetic evaluation of the bulls. Again, while going for extensive crossbreeding, it is also important to take note of the level of inheritance of exotic gene and choice of breeds, and supply of adequate feeds and fodder. Literatures indicate that the distribution of livestock being more equitable than land adoption of improved breeding technology is deemed to be anti-poverty and equity oriented. Various studies have highlighted that crossbreeding technology has favourable impact on milk yield, income, livelihood indicators such as food, health care and access to education, specialization and use of hired labour and creation of job opportunities with the dairy value chain. The reduction in herd size through crossbreeding helps in preventing degradation of forests and common grazing lands. Again, crossbreeding ensure much needed linkage between rural

producers and urban consumers. However, literatures also point out that crossbreeding programme have certain negative impact. It exacerbates the problem of feed scarcity, loss of milk production due to poor survival and high reproductive wastage. The programme could not result in desired impact due to lack of AI and veterinary aid facilities and repeat breeding.

Literatures on feeding highlight that in spite of having varied sources of roughages in India, there stands a formidable challenge to the farmers in a scenario where common grazing lands are on decline, competitions are rising for lands to grow food or fodder, limited application of chemical treatment technology for enhancing nutritive value of crop residues and lack of quality control measures for concentrates. This puts in paradoxical position where for the larger interests of productivity enhancements of the dairy sector several of the studies advocate for crossbreeding of the indigenous breeds with exotic breeds. However, it depends on supply of quality feeds and fodder and on the other side; the country is confronting a great challenge of meeting the feeds and fodder requirement in the foreseeable future. This necessitates enquiring at a ground level the farmer's access to feeds and fodder and conservation practices and their beliefs on future dairying in the context of the challenge. Again, proper dairy farm management and removal of constraints also play an important role in the adoption and maintenance of improved bovine stock. The major elements in the dairy farm management are herd size, farm profitability, animal healthcare etc. According to various studies, the various external factors that affect dairy farm management are collaboration between extension service providers and farmers, investment in physical infrastructure, availability of credit and factors influencing producers' market participation. Removal of constraints such as animal health problem, feed shortage, theft of animal, manure management, problem of repeat breeding and high rejection rate of crossbred bulls are of immense importance for pursuance and maintenance of crossbreeding programme.

Literatures on factors influencing adoption of crossbreeding technology point out that there are multiple factors likely to influence crossbreeding technology adoption. These factors, based on literatures, are categorized in four different categories, namely farm and farmers characteristics, physical environment at which farmers operate and perception factors. The

various farm characteristics highlighted in the available literatures are land size, land allotted for fodder cultivation, feeding concentrates to cows, access to credit, membership of Dairy Cooperative Society, herd size, extension visit/contact, income from milk sales and milk sold per month, off-farm income, duration of the farm, veterinary services etc. Farmers' personnel characteristics that are reported to significantly influence crossbreeding technology adoption in various studies are age and education of the household head, family size, farmers with children, farmers' knowledge about the technology, lack of sensitization about the benefits of AI etc. The physical environment characteristics at which the farmer operates influencing crossbreeding technology adoption are distance to market, distance to all weather road, access to grazing land, distance to AI centre, human population density and agro climates and availability of local breeding bull. Some studies are found to incorporate farmers' perception about the technology that has significant influence on uptake of crossbreeding technology. Some empirical studies also emphasize on the characteristics of the technology itself (such as AI technicians known, distance from farm to AI technicians and per AI service cost at farm and farm per bull service cost) to affect adoption of crossbreeding technology.

Notes:

¹ A crossbred animal with normal female cycling and normal genitalia is considered repeat breeder if she fails to settle to service or insemination during three or more consecutive oestrus periods.

² Intensification is defined as the livestock population per unit of arable land, i.e., stocking rate. Livestock intensification can also be measured as the ratio of livestock population to human population or feed use per livestock unit (see Birthal and Rao, 2004)

³ Adopters are defined as households with at least one crossbred or dairy animal at the time of the survey. Non-adopters are agricultural households with local animals or no animals at all (Baltenweck and Staal, 2000)

CHAPTER THREE

CROSSBREEDING TECHNOLOGY DIFFUSION, COMPOSITIONAL CHANGE OF BOVINE POPULATION AND MILK PRODUCTION DYNAMICS IN ASSAM

From the previous chapter it has been found out that crossbreeding through AI is an economically viable strategy to enhance productivity of low yielding indigenous milch animal. It is evident that it has implications on rising farmers' wellbeing through increased income, consumption and employment of the rural farm households as livestock is more equitably distributed compared to farm land. However, this may become possible provided constraints relating to feed and fodder supply, animal healthcare, extension services for better farm management, marketing of animal products etc are effectively overcome. The present chapter, based on available secondary data, makes an attempt to understand the crossbreeding scenario of Assam over the years since first organized attempt for bovine crossbreeding was made. The compositional changes taking place for bovine population and the dynamics in milk production of the state are tried to understand as a consequence of crossbreeding technology diffusion. The rest of the chapters are organized in five sections. Section 3.1 discusses the issues concerning crossbreeding technology diffusion in the state of Assam. Section 3.2 presents the analyses of the performances achieved after diffusion of crossbreeding technology in the state. The discussion on bovine population dynamics is presented in section 3.3. While section 3.4 deals with the dynamics in milk production in correspondence with crossbreeding of cattle, section 3.5 sums up the whole discussion of the chapter.

3.1. Crossbreeding Technology Diffusion in Assam: A Background

The effort for improving the indigenous cattle stock in the state of Assam through crossbreeding took place almost in the same time with the efforts laid at national level. The first organized attempt to improve the indigenous cattle for milk production was made in the state during the 1st Five Year Plan with introduction of Key Village Scheme (KVS) in the year 1953-54. Under the scheme, genetic upgradation of local non descript cows were tried by distribution of bulls of recognized Indian breeds like Haryana, Red Sindhi etc to villages

covered under Key Village Blocks. This plan helped in very small magnitude in some selected areas only. Moreover, the expected significant increase in production potentiality was not achieved because of low productivity of the Indian breeds compared to the exotic breeds.

Crossbreeding of cattle and upgrading of buffalo have been the main thrust of the breeding policy; the rationale being that new breeds are more productive and their unit cost of milk production is lower than the local nondescript animals (Dhas, 2002). The technical programme for crossbreeding adopted by the government was to use non-descript cattle as the foundation stock and to impregnate them using semen from exotic breeds. This produces half-breeds with equal inheritance from the two widely different parents on contributing endurance and the higher productivity (Rukmani et al., 2007). The basic ingredients of the present cattle breeding policy are discussed in section 3.1.1, 3.1.2 and 3.1.3 respectively.

3.1.1. Cattle Breeding Policy in Assam

According to the National Commission on Agriculture (1976), in all the cattle and dairy development projects, a clear cut breeding policy should be laid down in advance dealing with the exotic breeds to be used, level of exotic inheritance to be reached and the type of crossbred bulls to be used for inter-se-mating. Crossbreeding policy should broadly aim at producing crossbred stock with 50 to 75 per cent exotic inheritance. The Sixth Five Year Plan also stated that for increasing the productivity of cattle and buffaloes, and to contain the increase of its population each state should lay down a definite breeding policy (Singh, 1986). In Assam, the cattle breeding programme gained momentum in 1968-69 following Intensive Cattle Development Project (ICDP) with the introduction of Frozen Semen Technology. Under this project and as per the National Breeding Policy, introduction of Jersey semen was done but the level of exotic inheritance was not properly defined. By the end of 1985-86, the department was able to establish 11 ICDP centre, 26 Regional Artificial Insemination Centre (RAIC) and 547 stock man centre with a potential coverage of 1.1 million breedable cattle in Assam. However, reviewing the result of the cross breeding programme under ICDP the earlier policy was modified in 1980 which proposed to produce crossbred by utilizing inheritance from three different breeds. Crossing among Jersey (J), Red Sindhi (RS) and Local (L) is done with their respective inheritance of 50%, 25% and

25% to generate a population of cattle incorporating high yield of J and draftability of RS and L. However, this policy was again identified with some constraints such as (1) necessity of maintaining 3-phased breed type of J, RS and L and their crosses, (2) necessity of separate progeny testing (PS) programmes for above genetic groups, (3) non-availability of quality germ plasm of RS in particular and (4) the process being too complex and expensive.

The 1980 breeding policy emphasizing on maintenance of three breedline was again reviewed and a revised breeding Policy was established in the Year 1988 with the crossbreeding of exotic Jersey of high genetic merit with non-descript cattle of Assam to produce cross bred cattle with level of exotic inheritance of Jersey at 50% in major areas and 62.5 % in some selected areas. The second and revised breeding policy was notified in 30th December, 2002 vide Govt. notification No. VFV.255/2002/pt/23 Dtd. Dispur, the 30th Dec/2002. This policy was relatively simpler than the previous one as only two pure breed line (Jersey X Local) is to be maintained and will be continued for 20 years². Temperature plays an important role in the choice of bull to be used in the local condition. Kale and Basu (1993) find that lower temperature was conducive to the milk production of Jersey crosses but Holstein crosses are less affected by changes in temperature of the hot humid tropical climate of the eastern region. Sattar (1988) argues for the superiority of Jersey crosses to justify the incorporation of Jersey bulls in the cattle breeding policy (see Table 3.1).

Perusal of Table 3.1 reveals that the performance of Jersey crossbred in Assam's context indicates the superiority of administering AI using Jersey semen. The various parameters such as age at 1st calving, 1st lactation yield, lactation length (number of days), calving interval and milk yield indicate the comparative performance among the various breeds and their crosses has been shown in Table 3.1. It shows that the time requirement for local cattle of Assam to reach to the age of 1st calving is 1.6 times more than imported Jersey pure breed. The Jersey crossbred takes 35.5 months to reach to the age of 1st calving against 45 months for local pure breed. Again, the lactation length is much higher for Jersey crossbred than local pure (337 days versus 240 days) along with relatively higher daily milk yield (4.80 litres versus 0.80 litres). The calving interval is also shorter for Jersey crossbred than the local breed by 78 days (Table 3.1)

Table 3.1: Milk Production and Lactation Characteristics of Jersey Crossbred in Assam

Breed	Age at 1 st Calving (months)	1 st Lactation Yield (litres)	Lactation Length (days)	Calving Interval (days)	Milk Yield daily (litres)
Jersey (Imported)	27.5	2352	300	350	7.50
Jersey x Sindhi	35	1475	250	421	6.00
Jersey x Local	35.5	1288	337	437	4.80
Local	45	220	240	515	0.80

Source: Sattar (1988)

3.1.2. Basics of the Present Cattle Breeding Policy of Assam

3.1.2.1. Policy for Milk Production

Keeping in mind that the milk production is to be enhanced in the state there is the policy of upgrading of local low productive non descript cows by Jersey and HF through AI programme with different scale of implementation and requirement condition. According to the breeding policy notified in 30th December, 2002, in the crossbreeding of local cattle using jersey breed two levels of exotic inheritance (50% and 62.5%) will be followed in the state considering the climatic and basic infrastructural conditions. Table 3.2 points out the required conditions for maintaining the respective inheritance level.

Table 3.2: Conditions for Exotic Inheritance Level of Jersey Crosses in Assam

Level of exotic inheritance	
50 per cent	62.5 per cent
<ul style="list-style-type: none"> This applies to the entire state Large scale production of half breeds (50 per cent Jersey and 50 per cent Indigenous) will be the main goal. 	<ul style="list-style-type: none"> This will be done in limited scale On demand from farmers in some areas/herds, where there is plentiful of fodder availability, good marketing conditions, educated entrepreneur with knowledge and capability for providing better management

For the breeding policy to use HF to cross with Indigenous breed following important points are considered.

- HF inheritance will be infused only in limited scale.
- In some defined geographical areas or herds where fodder production and its availability is more and associated with a well developed milk marketing system. It

will also be favoured in areas of high elevation with favourable climate and most importantly when farmers put demand for it.

- The level of inheritance of HF in the crossbred will be fixed at 50 per cent by intense mating of the crossbred coupled with selection of superior F₁ animals.

3.1.2.2. Policy for Draftability

Though Assam does not have any recognized breed of cattle to conserve some areas of transport bottleneck are kept outside the network of crossbreeding programme. The local non-descript cattle are small in size with very low productivity but have draught power for long period. Farmers are encouraged to use Jersey half-bred for regular draft work. In a state like Assam, where many of the farmers rely on draught animals for carrying out several agricultural operations the breeding policy may fail if the policy nullifies the scope of draftability of cattle. There are three policy options for improvement of draft power in the state:

I. Policy for Using Jersey Half-bred (and graded) Male: The Jersey half-bred bullocks (Jersey x indigenous) have higher draft capacity for shorter working hours than the local ones. This will counter the inertia of poor draftability of Jersey crosses among the cattle keepers which is possible through practical demonstration of the short duration draught capacity of Jersey half-bred and through intensive extension activities to create awareness about it among farmers.

II. Policy for Using Indigenous Bullock: The policy aims at improving the draftability of indigenous cattle by selection and animal production and conservation of indigenous germ plasm to support this traditional system of draft animal utilization.

III. Upgradation of Local Cattle by Pure Indian Breeds: This upgradation programme aims at increasing both draft and milk production ability. Presently, Sahiwal, a pure Indian breed is being adopted experimentally in three districts of Assam to produce dual purpose animals.

3.1.3 Infrastructure Development for Crossbreeding Technology

For the crossbreeding programme to be successful there has to be adequate infrastructure and extension facilities. Lalwani (1987) also emphasizes that in order to intensify dairy

development efforts in all those districts where crossbreeding of cattle is seriously pursued, there has to be adequate provision of all the necessary veterinary and artificial insemination (AI) facilities at higher and more efficient level and extension services to dairy producers. According to Singh (1986), the most crucial point on which the success of crossbreeding programme depends is the quality of bulls used for breeding and the adherence to controlled crossbreeding. Again, Singh and Singh (1989) observe that for successful implementation of AI in bovines at the field conditions farmer's knowledge on reproduction system of the animal, quality of semen used and the sterilization of equipments required in addition to adoption of sound breeding and management practices.

Frozen semen production for large scale AI coverage is the prime requirement in the cattle breeding policy⁵. The deep frozen semen bank was established under Indo-Australian Cattle Breeding Project at Khanapara, Guwahati, which was commissioned in March, 1976 with a view to replace chilled semen with frozen semen (FS) and to assure supply of semen at proper inheritances as per state cattle breeding policy. The station was strengthened under World Bank aided project, Assam Rural Infrastructure and Agricultural Services Project (ARIASP) to produce medium FS straws. During the year 2004-05, State Implementing Agency (SIA) of National Project for Cattle and Buffalo Breeding (NPCBB) under the recommendations of Department of Animal Husbandry, Dairying and Fisheries, Govt. of India was created in Assam by the name of Assam Livestock Development Agency (ALDA). ALDA renovated the station within limited available space and under NPCBB Phase-I as per the standard set by Minimum Standard Protocol (MSP). The production capacity was enhanced after renovation from 0.95 Lakh to 3 Lakh doses/year. The station was also producing the required F₁ semen for inverse mating to keep the exotic inheritance at desired level as per the requirements of breeding policy. But, as there is very limited scope for further renovation and expansion in Khanapara, government of Assam decided to start a new semen station at centrally located Barapetta (in Barpeta district). For this, financial assistance was received from Govt. of India under NPCBB Phase-II and the station started to commission from the year 2014.

ALDA introduced AI facility to all districts (including two hill districts and Lakhimpur, Dhemaji and BTAD areas etc) of the state as per guideline of Govt. of India with

introduction of AI centre in 300 non AI departmental centres and with the training of 280 private AI workers for better coverage in interior most areas. Recently, under *Rastriya Krishi Vikash Yojna* (RKVY) the AI network has been expanded to all veterinary establishments (total 1275 centres) in the state. Again, for strengthening the distribution network, under ARIASP 7 Frozen semen Banks (FSBs) were renovated and established in seven strategic locations to cater the needs of the 15 districts. Under NPCBB 4 more FSBs (in Kokrajhar, North Lakhimpur, Mania and NC Hills) were also introduced. All the FSBs were equipped with bulk liquid nitrogen (LN) silos to establish a LN grid and LN distribution vehicles for uninterrupted supply of LN and frozen semen to cover the entire rural AI network (see Table 3.3). For bulk transportation of LN from sources of LN to FSBs procurement of the first bulk LN transport tanker of the state took place under NPCBB. Again, ALDA supplied 10 emergency liquid nitrogen carrying vans for distribution of LN and FS from the existing FSBs to all the rural village level AI centres with the help from RKVY bearing the recurring cost for fuel and LN so that AI can be performed at the farmers' door step from the rural AI centres. Moreover, all existing FSBs and AI Centres were strengthened under NPCBB with storage cryo cans and transport type cans to facilitate doorstep AI service of interior most areas from their nearest AI centres. ALDA procured and supplied 104 transport type cryo cans for strengthening of the LN transportation to the AI centres during 2004-05.

For the production of quality bulls for frozen semen production the Old Bull Mother farm Barapetta located at Barpeta district was also renovated under ARIASP and Jersey bulls were brought to cater the need of FS. The old farm sheds were again renovated and strengthened with Jersey bulls and Holstein Friesian bulls under NPCBB.

The AI expansion in the state kept the demand for quality Frozen Semen manifold, for which a new state of the art frozen semen bull station is being constructed at Barapetta under NPCBB, as the 40 years old existing Khanapara semen station does not have scope for expansion and capacity enhancement to meet the ever increasing demand of frozen semen. To accommodate the requirement of bulls ALDA renovated 3 old bull sheds of Barapetta Bull mother farm to house the bull calves for use in the semen station. Jersey purebred bull calves brought from Central Cattle Breeding Farm (CCBF), Sunabeda were housed in those

renovated sheds. On attaining maturity the bulls are transported to Khanapara FSBS for semen production. Again, for responding the heavy demands from farmers, 8 young purebred HF bull calves were procured for semen production purpose from CCBF, Hessarghatta, Bangalore and transported to Barapetta farm on 22nd March, 2013. This is for the first time that HF bull is procured for state AI programme for semen production. Presently these valuable animals are managed in the newly renovated sheds of Barapetta bull mother farm under regular supervision of the deployed officers trained under NPCBB phase-II at Central Frozen Semen Production and Training Institute (CFSPTI), Hessarghatta, Bangalore.

To utilize the improved infrastructure in proper scientific way for better public service 1089 field AI workers of State Animal Husbandry and Veterinary Department were trained on reproductive techniques in Phase I and 1125 were trained in phase II. This training was carried out for efficient and correct field AI service for the benefit of the farmers and economic use of LN at Rani, Demow and Ghungoor training centres situated in three different zones of the state. These three centres, renovated under NPCBB were also utilized for training of 280 private AI workers who are presently working in their allotted fields. Again, 32 and 19 field veterinary officers were trained in central government training institute at Hessarghatta under NPCBB phase-I and phase-II respectively on field AI management, FS technology and Quality Control. There was the expectation behind training of the field veterinary officers that these trained officers can provide technical guidance to the field AI workers of their respective area for better AI service.

Farmers tend to have a favourable attitude towards natural services compared to AI and this reduces the success rate of AI (Ghosh and Chand, 2001). In Assam, though AI programme was effectively initiated much before, i.e. 40 years from now in the state but due to diverse agro climatic, socio-cultural and geographic conditions there are still some remote rural areas and hill districts where there is necessity for AI extension programmes to make the farmers aware of the new and profitable breeding techniques available at their door step. The initiatives of semen production and distribution become futile unless sufficient efforts are not laid to popularize the benefits of the technology. This calls for laying emphasis on awareness Programme for increased AI adoption level of dairy technology which may

depend on information source utilization such as farm visit, film show, cattle rally as popular information sources (Nataraju and Channegowda, 1988). In Assam, there have been such awareness programmes carried out such as awareness on cattle management and fodder production, field awareness programme like fertility camps, treatment camps, vaccination camps, farmers' meet, Friday evening meeting, training programme on crossbred cow management, fodder management in and outside of the state conducted under ARIASP, NPCBB and RKVY Schemes.⁶ TV documentary and Radio jingles were aired for benefit of the farmers to motivate people especially from the tribal and hill community for rearing crossbred animals for higher milk production as well as enhancement of their economic status.

3.1.4 Initiatives for Semen Production and Expansion of AI Network in Assam

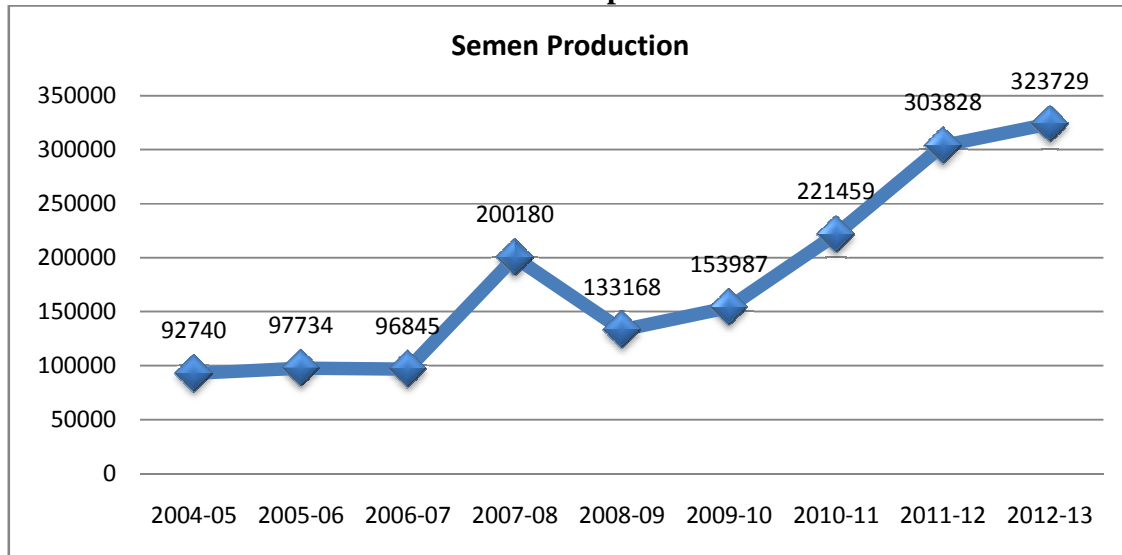
The Primary objective of ALDA is clean and quality semen production. For this ALDA in the year 2005-06 renovated the civil structures of more than 40 years old (1968-69) semen station in Khanapara and equipped with modern machineries of FS production as per guidance of central monitoring unit (CMU), a government of India regulatory body and established a quality control lab. ALDA bought 6, 8 and 11 new pure breed jersey bull calves of high pedigree from Central Cattle Breeding Farm (CCBF), Sunabeda, Orissa in 3 phases out of which 14 are used for semen production and 11 kept for training purpose. Respecting the demand of the farmer ALDA brought 3 HF bulls from Karbi Anglong mini ICDP to meet the demand in 2007-08. After renovation and making the station upto a graded station within the limited available space it has achieved the production capacity of above 3.00 lakh frozen semen doses and has planned to increase up to 5 lakhs as per the need of expansion programme till the completion of new FSBS at Barapetta. The quality of the FS produced is evident from the calving rate of the semen produced in this FSBS as it is 40-41 per cent which is relatively higher than the national average of 37 per cent.

3.1.4.1 Semen Production

Smooth and uninterrupted propulsion of FS and LN is a lifeline of breeding programme using FS. The Frozen Semen Bank Station, Khanapara achieved the production capacity of 3,23,729 doses during the year 2012-13 from a production of 92,740 doses during 2004-05. This increase in FS production has been possible due to the renovation done by ALDA since

its formation in September 2004. The semen production in the state has been continuously increasing during the post ALDA formation period (see Figure 3.1).

Figure 3.1: Semen Production of Existing Frozen Semen Bank Station at Khanapara



Source: Assam Livestock Development Agency (ALDA), Khanapara, Assam

3.1.4.2 Semen Distribution

Table 3.3 reports breed-wise distribution of FS in the last 7 years that includes FS of Jersey, Crossbred Jersey, HF, Crossbred HF and Sahiwal. FS of Jersey and HF purebred is relatively popular among farmers. Again, Jersey semen is widely used in the state because of

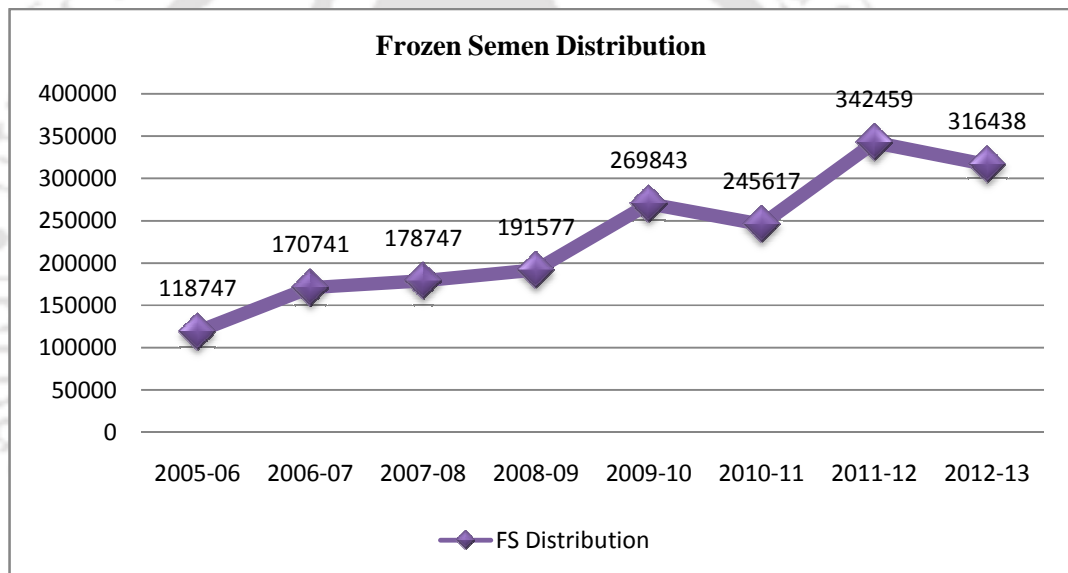
Table 3.3: Breed-wise Semen Distribution for the Last 7 Years in Assam

Breed	Year							Total
	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	
Jersey	154156	150304	169760	239583	190331	267378	234180	1405692
Crossbred Jersey				5081	14830	25743	21940	67594
HF	16585	28443	21817	23679	28219	28199	45174	192116
Crossbred HF					12237	21139	7772	41148
Sahiwal							7372	7372
Total	170741	178747	191577	268343	245617	342459	316438	1713922

Source: Assam Livestock Development Agency (ALDA), Khanapara, Assam

the content in the latest breeding policy of the state that exclusively focuses on mating of Jersey with indigenous cattle. The distribution of FS of crossbred Jersey and crossbred HF started lately, i.e., from 2009-10 and 2010-11 respectively for inter-se-mating in order to keep the level of exotic inheritance at desired level. The FS of high yielding Indian breed, Sahiwal was distributed in 2012-13 though it does not exist in any of the official breeding policy of the state. It is evident from Table 3.3 that during the last 7 years a total of 17,13,922 doses were distributed of all the breeds mentioned which has been possible due to the efforts laid by ALDA and sponsorship of its activities by NPCBB phase I and phase II. Figure 3.2 displays the rising trend of FS distribution in the state.

Figure 3.2: FS Distribution Trend in Assam during 2005-06 to 2012-13



Source: Assam Livestock Development Agency (ALDA), Khanapara, Assam

3.1.4.3 Artificial Insemination Network

For improving the AI service in a state expansion of AI network in terms of increasing the number of AI centres along with adequate number of inseminators in the centres play an important role. A scattered distribution of AI centres may result in spatially uneven performance of crossbreeding technology. Rathore et al. (2009) in their study in Rajasthan report that Lack of AI centre is the most severe constraint in the adoption of recommended breeding practices. In Assam, to expand the breeding network 1275 AI centres were formed

Table 3.4: District-wise Distribution of Artificial Insemination Centre and its Sources and Breedable Population per Centre (2013)

Districts	Number of AI Centre			Total	Breedable population per AI Centre
	ARIASP	RKVY (2011-12)	ALDA		
Goalpara	9(24.32)	25(67.57)	3(8.11)	37 (100)	2203.99
Dhubri	17(25.76)	27(40.91)	22(33.33)	66(100)	2808.13
Kokrajhar	3(6.82)	22(50)	19(43.18)	44(100)	3340.29
Bongaigaon	14(51.85)	8(29.63)	5(18.52)	27(100)	3535.31
Barpeta	44(53.01)	21(25.30)	18(21.69)	83(100)	2335.89
Nalbari	35(66.04)	1(1.89)	17(32.08)	53(100)	1758.28
Baska	7(15.56)	30(66.67)	8(17.78)	45(100)	2615.40
Kamrup	56(65.12)	20(23.26)	10(11.63)	86(100)	3241.24
Darrang	20(57.14)	3(8.57)	12(34.29)	35(100)	3409.62
Udalguri	8(50)	4(25)	4(25)	16(100)	8469.91
Sonitpur	52(60.47)	19(22.09)	15(17.44)	86(100)	2963.69
Lakhimpur	10(25)	18(45)	12(30)	40(100)	4116.72
Dhemaji	0(0)	21(65.63)	11(34.38)	32(100)	4220.87
Morigaon	15(35.71)	16(38.10)	11(26.19)	42(100)	2780.82
Nagaon	41(42.71)	36(37.50)	19(19.79)	96(100)	3163.18
Golaghat	25(54.35)	8(17.39)	13(28.26)	46(100)	3493.24
Jorhat	23(32.39)	42(59.15)	6(8.45)	71(100)	2768.31
Sibsagar	24(38.71)	23(37.10)	15(24.19)	62(100)	2392.84
Dibrugarh	25(59.52)	14(33.33)	3(7.14)	42(100)	4039.25
Tinsukia	22(40.74)	7(12.96)	25(46.30)	54(100)	2076.68
Chirang	2(10.53)	13(68.42)	4(21.05)	19(100)	5577.71
Karbi	0(0)	38(60.31)	25(39.68)	63(100)	2146.5
Anglong					
NC Hills	4(14.81)	19(70.37)	4(14.82)	27(100)	614.47
Karimganj	7(25)	19(67.86)	2(7.14)	28(100)	3875.68
Hailakandi	22(91.67)	2(8.33)	0(0)	24(100)	2145.12
Cachar	28(54.90)	6(11.76)	17(33.33)	51(100)	2771.44
Assam Total	513(40.24)	462(36.24)	300(23.53)	1275(100)	3042.30

Source: Assam Livestock Development Agency (ALDA), Khanapara, Assam

Note: 1. Figures in parentheses indicates percentage to total.

2. Breedable population pertains to the 2007 livestock census of Assam

by three different programmes attached to dairy development in the state. The Assam Rural Infrastructure and Agricultural Services Project (ARIASP) of the World Bank started to work from 1996 on cattle breed improvement programme in the state. Under this project the Animal Husbandry and Veterinary Department restructured and strengthened AI activity with frozen semen distribution in 15 districts with 513 AI centres. ALDA, under the sponsorship of NPCBB, introduced AI facility to all the districts (including two hill districts and Lakhimpur, Dhemaji and BTAD areas etc.) of the state as per guideline of Govt. of

India with introduction of AI in 300 non-AI departmental centres. Recently, under *Rashtriya Krishi Vikash Yojana* (RKVY), the AI network has been expanded to all veterinary establishments. Thus, out of total 1275 AI centres in the state ARIASP, RKVY and ALDA individually account for 40.24 per cent, 36.24 per cent and 23.53 per cent respectively. At district level, Nagaon (96) has the highest number of AI centre followed by Sonitpur and Kamrup each with 86 centres. Again, the breedable population per AI centre is highest in Udalguri district (8470) and lowest in NC Hills (614) (see table 3.4).

Reaching out to the farmers beyond the expanded AI network: ALDA took crossbred bull calf distribution programme for natural service in the transport bottleneck areas under NPCBB Phase I as per the guideline of Govt. of India where AI service network cannot reach to the farmers. Table 3.5 presents the distribution of crossbred bull calf by ALDA in interior most areas of some of the districts of Assam where diffusion of AI services was considered to be cumbersome. A total of 93 such bull calves were distributed in Dhubri, Goalpara, Dhemaji, Lakhimpur, Karbi Anglong and NC Hills during 2006-07 of which 11 died and presently 82 are left for service. Sasidhar et al, (2004) remarks that there is a need for strengthening the bull mother farm so that more such bulls of high genetic merit can be distributed to the interior most areas where diffusion of AI service is practically difficult.

Table 3.5: Distribution of Crossbred Bull Calf Distributed as an Alternative to AI in Inaccessible Areas

District	Total nos. distributed	Death Occurred	Present Status
Dhubri (2006)	15	0	15
Goalpara (2006)	15	3	12
Dhemaji (2006)	15	3	12
Lakhimpur (2006)	15	5	10
Karbi Anglong (2007)	20	0	20
NC Hills (2007)	13	0	13
Total	93	11	82

Source: Assam Livestock Development Agency (ALDA), Khanapara, Assam

Induction of private A.I. workers (Gopal Mitra): Expansion of breeding network not only depends on the spread of AI centre and distribution of frozen semen and liquid nitrogen but also depends on diffusion of efficient service providers. National Commission on Agriculture (1979) emphasized the system of entrusting insemination work to village educated youths that would enable increased coverage and economy in the provision of AI

services. Sasidhar et al. (2004) remarked by saying that the system of entrusting AI work to village educated youths would enable increased coverage of AI and economy in the provision of AI service besides solving unemployment problem to a certain extent. In this backdrop, recently there have been efforts undertaken in most of the states in India to assign the provision of AI services to village educated youths as private AI worker. Introduction of private AI worker in the name of *Gopal Mitra* was based on fulfilling the twin objectives of employment generation and spread of AI technician (as per guideline of NPCBB, Govt. of India).⁷ ALDA trained and established 280 numbers of educated unemployed youths as private AI workers (*Gopal Mitra*) as a means of alternate employment generation. Demow and Rani training centres were renovated under NPCBB phase-I for the purpose of training the *Gopal Mitra*.

In order to have insights into the performance of *Gopal Mitra*, the district-wise share of veterinary staff and private AI worker in performing the AI service and its corresponding number of calf born for the year 2013-14 is presented in Table 3.6. The total number of AI done in Assam, as on 2013-14, is 3,23,883 with corresponding figure of calf born as 1,13,360. It is evident from Table 3.6 that number of AI done is the highest in Barpeta district (60,063) followed by Kamrup district (49,566) and the lowest being in Dhemaji district (396) followed by NC Hills (447). The reason for the lowest number of AI done figure in these two districts may be attributed to the poor AI network in these two districts. The poor AI network results from one being frequently flood affected (Dhemaji) as flood causes major seasonal disruption in AI service delivery and the other (NC Hills) being geographically cumbersome to spread the service for the district's landscape being a hilly terrain. The concerned department shows reluctance to set up AI centres in these districts because of the reasons cited above. There has been a gradual spread of AI done by the private AI worker with more number of such persons being trained over the years to practise AI by the Assam Livestock Development Agency (ALDA). Till 2013-14, the proportion of AI done by the private AI worker has been 6.31 per cent (20,438) in the state against 93.69 per cent (3,03,445) done by the veterinary staff with corresponding proportion of calf born of 5.39 per cent and 94.61 per cent for private AI worker and veterinary staff respectively. At district level, the proportion of AI done by private AI worker is the highest in Morigaon district (24 per cent) followed by Lakhimpur (17 per cent) and Sonitpur district (16.78 per

cent) with corresponding calf born proportion of 21 per cent, 15.63 per cent and 14 per cent respectively. The service delivery by private AI worker has not taken place in districts such as Dibrugarh, Bongaigao, K. Anglong, Dima Hasao and Dhemaji (see Table 3.6).

Table 3.6: District-wise Distribution of AI Done and Calf Born between Staff and Gopal Mitras (2013-14)

District	AI Done		Total AI Done	Calf Born		Total Calf Born
	Staff	GM		Staff	GM	
Barpeta	56716 (94.43)	3347 (5.57)	60063 (100)	16831 (94.76)	931 (5.24)	17762 (100)
Cachar	9822 (99.08)	91 (0.92)	9913 (100)	4584 (99.37)	29 (0.63)	4613 (100)
Darrang	14227 (88.01)	1938 (11.99)	16165 (100)	4275 (86.70)	656 (13.30)	4931 (100)
Dibrugarh	6455 (100)	0 (0)	6455 (100)	2631 (100)	0 (0)	2631 (100)
Golaghat	7393 (97.96)	154 (2.04)	7547 (100)	3885 (93.82)	256 (6.18)	4141 (100)
Hailakandi	6168 (98.67)	83 (1.33)	6251 (100)	3379 (99.29)	24 (0.71)	3403 (100)
Jorhat	10669 (99.78)	23 (0.22)	10692 (100)	4779 (99.77)	11 (0.23)	4790 (100)
Kamrup	45816 (92.43)	3750 (7.57)	49566 (100)	15734 (93.24)	1140 (6.76)	16874 (100)
Karimganj	4983 (98.19)	92 (1.81)	5075 (100)	2050 (98.42)	33 (1.58)	2083 (100)
Morigaon	10548 (76)	3331 (24.00)	13879 (100)	3088 (78.72)	835 (21.28)	3923 (100)
Nagaon	34330 (92.68)	2711 (7.32)	37041 (100)	10084 (95.01)	529 (4.98)	10613 (100)
Nalbari	20511 (98.57)	298 (1.43)	20809 (100)	7515 (98.88)	85 (1.12)	7600 (100)
Sibsagar	9648 (99.40)	58 (0.60)	9706 (100)	4923 (99.94)	3 (0.06)	4926 (100)
Sonitpur	10892 (83.22)	2196 (16.78)	13088 (100)	4570 (86.10)	738 (13.90)	5308 (100)
Tinsukia	9246 (99.44)	52 (0.56)	9298 (100)	3419 (98.30)	59 (1.70)	3478 (100)
Bongaigaon	13784 (100)	0 (0)	13784 (100)	4376 (100)	0 (0)	4376 (100)
Karbi Anglong	2057 (100)	0 (0)	2057 (100)	668 (100)	0 (0)	668 (100)
Dhubri	8974 (95.93)	381 (4.07)	9355 (100)	3518 (98.74)	45 (1.26)	3563 (100)
Goalpara	3764 (96.17)	150 (3.83)	3914 (100)	1213 (95.89)	52 (4.11)	1265 (100)
Lakhimpur	1253 (82.93)	258 (17.07)	1511 (100)	680 (84.37)	126 (15.63)	806 (100)
Kokrajhar	4044 (96.54)	145 (3.46)	4189 (100)	762 (94.42)	45 (5.58)	807 (100)
Baska	5489 (87.45)	788 (12.55)	6277 (100)	1913 (86.68)	294 (13.32)	2207 (100)
Chirang	2926 (90.62)	303 (9.38)	3229 (100)	811 (88.83)	102 (11.17)	913 (100)
Udalguri	2887 (90.90)	289 (9.10)	3176 (100)	1363 (92.72)	107 (7.28)	1470 (100)
Dima Hasao	447 (100)	0 (0)	447 (100)	113 (100)	0 (0)	113 (100)
Dhemaji	396 (100)	0 (0)	396 (100)	87 (100)	0 (0)	87 (100)
Total	303445 (93.69)	20438 (6.31)	323883 (100)	107251 (94.61)	6109 (5.39)	113360 (100)

Source: Assam Livestock Development Agency, Khanapara, Assam.

Note: Figures in parentheses indicate percentage to total.

Given the initiatives undertaken in the form of breeding policy formulation, development of infrastructure for diffusion of crossbreeding technology and semen production and expansion of AI network, there is the need to evaluate the extent of AI done and corresponding calf born in the state along with coverage of breedable population. The performance achieved in the crossbreeding programme of the state under the parameters mentioned in the preceding section is discussed below

3.2. Performance of Crossbreeding Technology Diffusion

Based on the various initiatives undertaken for AI related infrastructure development, expansion of breeding network and to create awareness among farmers to adopt AI, this section emphasizes on the evaluation of performances under various parameters of crossbreeding technology diffusion. It is noted in a study by Sasidhar et al. (2004) that there exists a great scope of increasing the number of inseminations by door step delivery of AI through mobile AI units, after organizing short duration training programme from time to time for the field technicians, since the cost per calf born decreases as the successful inseminations increase. Recently it has also been observed that the extent of farmers' resistance to get their scrub bulls castrated was decreased to a very great extent if comparison is made with the days when crossbreeding programme was newly introduced in 1960s. The performance level of AI programme in Assam has therefore been discussed in the present situation under the parameters mentioned above.

In Assam, there has been rapid increase in the number of AI done and its corresponding calf born figure in Assam since 1996-97 when ARIASP took the initiative of AI service expansion in the state in 1996 and subsequently by ALDA from 2004 onwards. In 1996-97, number of AI done in the state was only 17,000 which rose to 3,23,883 in 2013-14 with an annual growth rate of 18.93 per cent during the period under consideration. Again, the number of calf born in the state during 1997-98 was 9,152 which rose to 1,13,360 with an annual growth rate of 17.03 per cent (see Table 3.7). Table 3.7 further shows the year-wise conception rate of the AI done in the state. The average conception rate across the years under consideration has been 37.03 per cent. Poor conception rate, i.e., the problem of repeat breeding is reported in several of the studies (Ghose and Chand, 2001; Singh and Chauhan, 2006; Agarwal et al., 2007; Yadav et al., 2008; Kumar et al., 2009; Rathore et al., 2009a) conducted in various parts of India. The average conception rate in Assam is almost the same with what Singh and Singh (1989) found in their study conducted in Izatnagar, Uttar Pradesh (37.5) with average number of AI services per conception under field condition worked out to be 2.6. Again, the conception rate varies widely across all the years under consideration with highest conception rate during 1999-2000 (47.12 per cent) with average number of services required per calf born was 2.1 and the lowest being 24.8 per cent during 2001-02 with average number of services required per calf born was as high as 4. These variations in the conception rate across years may have the implication that the

production/storage standards of the semen and time interval of semen distribution from production centre to insemination centres to maintain its quality consistent across years is not uniform.⁸ Persistency in the performance level of the service providers (based on comparison of performance of stockman in mobile versus permanent AI station) is also a question mark.⁹

Table 3.7: Number of AI done, Calf Born and Conception Rate in Assam (1996-97 to 2013-14)

Year	AI Done	Calf Born	Conception rate
1996-97	17001	NA	
1997-98	32912	9152	27.81 (3.6)
1998-99	30850	14360	46.55 (2.1)
1999-00	34919	16453	47.12 (2.1)
2000-01	49250	19945	40.50 (2.5)
2001-02	90842	22529	24.80 (4.0)
2002-03	88033	24834	28.21 (3.5)
2003-04	109499	37898	34.61(2.9)
2004-05	96361	37982	39.42 (2.5)
2005-06	112913	39172	34.69 (2.9)
2006-07	124138	52246	42.09 (2.4)
2007-08	119611	51214	42.82 (2.3)
2008-09	142503	52232	36.65 (2.7)
2009-10	214039	73510	34.34 (2.9)
2010-11	210546	87915	41.76 (2.4)
2011-12	195139	64888	33.25 (3.0)
2012-13	260778	104212	39.96 (2.5)
2013-14	323883	113360	35.00 (2.9)

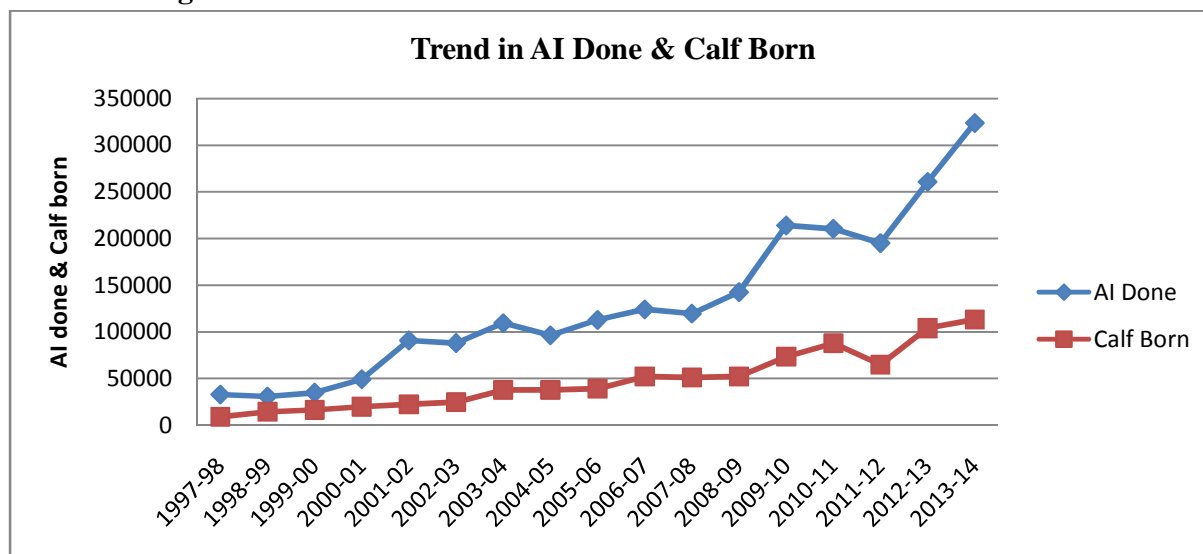
Source: Assam Livestock Development Agency, Khanapara, Assam.

Note: 1. Figures in parentheses indicate number of services required per calf born.

2. NA= Data not available

Figure 3.3 displays a rising trend in the number of AIs done and calf born in Assam from 1997-98 to 2013-14. However, in certain years there was a fluctuation in the growth trend of AI done and number of calf born. The years such as 2002-03, 2004-05 and 2011-12 exhibited a marked fall in the number of AI done in the state compared to its preceding year. Similarly, 2007-08 and 2011-12 also showed a decline in the number of calf born in relation to its previous year.

Figure 3.3: Trend in Number of AI Done and Calf Born in Assam



Source: Assam Livestock Development Agency (ALDA), Khanapara, Assam

The district-wise male and female calf born figure with respect to AI done and the ratio of male to female calf born during 2013-14 is presented in Table 3.8. It is noted that Barpeta district has the highest number of AI done figure (60,063) followed by Kamrup District (49,566) with corresponding calf born figure of 17,762 and 16,874 respectively. The highly flood affected district of the state, Dhemaji has the lowest AI done figure (396) followed by Dima Hasao (447) during 2013-14. The ratio of male to female calf born is an important determinant of subsequent adoption rate of AI technology. It often discourages the farmers to opt for AI service due to the stereotypical belief among farmers that AI leads to more male calf born. Table 3.8 reports on this aspect that in the state as a whole the calf born sex ratio is 50:50, but there is variation across districts. The average sex ratio of calf born has been highly favourable towards male calf in districts such as Goalpara (1.24), Hailakandi (1.17) and Tinsukia (1.12), whereas the same is favourable towards female calf in districts like Lakhimpur (0.82), Sibsagar (0.86), Jorhat (0.88), Darrang (0.89) and Dhemaji (0.89). Regarding conception rate of total calf born with respect to AI done, it is 35 per cent for the state as a whole but there is wide variation in conception rate across districts in Assam based on the AI done and calf born figure during 2013-14. Districts such as Golaghat, Hailakandi, Lakhimpur, and Sibsagar have more than 50 per cent conception rate while the rest of the districts have below 50 per cent. Districts such as Kokrajhar, Morigaon, Nagaon, Dima

Hasao etc. have a lower conception rate than the state average. Barpeta district which has the highest AI done figure in the state as a whole have a much lower conception rate. The variation in conception rate across districts implies that the quality of FS used and/or competency of the AI service providers may have significant variations across districts.

Table 3.8: District-wise Male and Female Calf Born with Respect to AI Done in Assam (2013-14) (In numbers)

District	AI done	Calf Born		Total Calf Born	Ratio of Male to Female
		Male	Female		
Barpeta	60063	8945	8817	17762 (29.57)	1.01
Cachar	9913	2362	2251	4613 (46.53)	1.04
Darrang	16165	2319	2612	4931 (30.50)	0.89
Dibrugarh	6455	1354	1277	2631 (40.76)	1.06
Golaghat	7547	1992	2149	4141 (54.87)	0.93
Hailakandi	6251	1834	1569	3403 (54.44)	1.17
Jorhat	10692	2247	2543	4790 (44.80)	0.88
Kamrup	49566	8426	8448	16874 (34.04)	1.03
Karimganj	5075	1047	1036	2083 (41.04)	1.01
Morigaon	13879	1984	1939	3923 (28.27)	1.02
Nagaon	37041	5469	5144	10613 (28.65)	1.06
Nalbari	20809	3971	3629	7600 (36.52)	1.09
Sibsagar	9706	2277	2649	4926 (50.75)	0.86
Sonitpur	13088	2512	2796	5308 (40.56)	0.99
Tinsukia	9298	1827	1651	3478 (37.41)	1.12
Bongaigaon	13784	2141	2244	4385 (31.81)	0.95
Karbi	2057	319	349	668 (32.47)	0.91
Anglong					
Dhubri	9355	1837	1726	3563 (38.09)	1.06
Goalpara	3914	700	565	1265 (32.32)	1.24
Lakhimpur	1511	364	442	806 (53.34)	0.82
Kokrajhar	4189	395	412	807 (19.26)	0.96
Baska	6277	1089	1118	2207 (35.16)	0.97
Chirang	3229	444	469	913 (28.28)	0.95
Udalguri	3176	704	766	1470 (46.28)	0.92
Dima Hasao	447	57	56	113 (25.28)	1.02
Dhemaji	396	41	46	87 (21.96)	0.89
Total	323883	56657	56703	113360 (35.00)	1.00

Source: Assam Livestock Development Agency, Khanapara, Assam

Note: Figures in parentheses indicate conception rate of the AI done

The coverage of breedable cattle population exhibits considerable progress from 2004-05 to 2012-13 due to extensive awareness and expansion of breeding network. Sasidhar et al. (2004) observe that farmers have recently developed positive attitude towards AI and crossbreeding in Assam compared to its previous periods. In the state, initially, in 2004-05 most of the districts did not come under the coverage of AI programme but eventually (from

2011-12) it became universalized to all veterinary establishments. During the decade of 2004-05 to 2013-14, AI coverage of breedable population increased by 12.82 per cent per year in the state with the coverage of 8.6 per cent in 2013-14 from 3 per cent in 2004-05 (see Table 3.9). According to the data collected from monitoring cell, ALDA, in middle Assam districts where demand for milk is high and availability of fodder and concentrate feed is relatively easy, the coverage of breedable population shows considerable improvement (6.09 per cent in 2004-05 to 15.35 per cent in 2012-13), especially in districts like Barpeta and Kamrup. The coverage was at par with the national average, but in Barak valley, due to difficult road condition, flood and low demand for milk in particular areas, the figure shows less improvement (2.38 per cent to 7.97 per cent). Similarly, in hill districts where demand for milk and availability of fodder and concentrate feed are low and the AI programme started from 2008-09 only the coverage was 2.09 per cent during 2013-14. In flood affected Lakhimpur and Dhemaji and in Bodoland Territorial Area Districts (BTAD) the AI programme using frozen semen started in 2008-09 and 2009-10 only and thus shows

Table 3.9: District-wise AI Coverage of Breedable Population during 2004-05 to 2013-14 (In percent)

District	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Barpeta	7.2	9.24	11.77	9.55	12.57	18.26	17.69	23.16	23.11	30.98
Cachar	2.05	3	4.06	2.47	3.13	4.87	4.1	5.54	5.73	7.01
Darrang	4.39	4.67	2.21	5.43	6.21	11.06	11.09	11.99	8.58	13.55
Dibrugarh	2.25	2.11	2.2	2.21	2.33	3.27	2.84	3.35	3.26	3.8
Golaghat	0.8	1.96	1.77	2.18	2.24	2.9	3.13	3.9	4.36	4.7
Hailakandi	3.65	4.19	7.04	5.01	6.63	9.36	7.38	10.45	10.97	12.14
Jorhat	2.17	3.3	3.26	3.14	4.26	4.77	4.04	4.94	5.19	5.44
Kamrup	9.2	11.73	16.06	5.65	6.12	12.72	12.99	15.31	15.31	17.78
Karimganj	1.44	2.29	2.73	2.38	1.95	3.45	3.12	3.99	3.11	4.68
Morigaon	1.55	4.97	4.4	4.86	6.01	7.99	6.84	9.94	10.93	11.88
Nagaon	5.37	6.31	5.55	4.13	5.06	7.01	7.28	9.57	10.14	12.2
Nalbari	7.14	7.16	8.73	10.4	10.56	13.59	12.11	18.03	17.32	22.33
Sibsagar	3.41	4.91	4.07	4.53	4.76	5.75	4.75	5.55	5.54	6.54
Sonitpur	5.59	5.9	5.13	4.53	4.37	7.28	6.25	6.59	6.17	5.14
Tinsukia	1.07	1.56	1.24	2.83	4.03	4.41	5.03	6.45	7.63	8.29
Bongaigaon			3.28	3.96	3.62	8.09	7.77	12.06	6.95	14.44
K. Anglong				0.41	1.4	1.63	2.62	2.31	2.27	1.52
Dhubri				1.08	1.31	0.83	2.35	3.98	2.71	5.05
Goalpara				0.46	0.85	1.59	1.79	3.11	3.76	4.8
Lakhimpur				0.47	0.97	1.13	1.31	2.15	1.55	0.92
Kokrajhar					0.84	1.14	1.22	2.46	1.32	2.85
Baska					0.49	1.1	2.52	4.6	3.47	5.33
Chirang					0.6	1.38	1.59	1.4	1.15	3.05
Udalguri								2.11	2.25	2.34
Dima Hasao					1.88	1.9	2.74	3.31	1.71	2.67
Dhemaji						0.19	0.15	0.1	0.06	0.29
Assam	2.9	3.68	4.04	3.17	3.78	5.68	5.59	7.24	6.92	8.59

Source: Assam Livestock Development Agency (ALDA), Khanapara, Assam

abysmally low coverage of less than 1 per cent (Lakhimpur and Dhemaji) and 3.57 per cent (BTAD districts). Expansion of AI to the hilly areas and interior and remote areas remains a major constraint because natural service likely to dominate breeding programme in the coming years till the development of complete infrastructure (Sasidhar et al., 2004). In comparison to the infrastructure created for AI programme and expenditure incurred, the adoption of AI in dairy animals is not encouraging which can be due to many factors. Studies report that at farmers' level the reasons for non-adoption of crossbred cattle are that crossbred cattle is susceptible to various diseases, lack of tolerance to sun heat (Gupta and De, 1989; Singh et al., 2007), unfit for carting and other field operations (Ghosh and Chand, 2001) and requirement of extra care as compared to local cows (Yadav and Jain, 1984).

3.3 Bovine Population Dynamics in Assam

The bovine category of livestock population consists of Cattle, buffalo, Yak and Mithun. But in the context of Assam, the Yak and Mithun being non-existent in the state, only cattle and buffalo combined is considered as bovine population. Bovines are instrumental in the state both for milk production and supply of drought capacity apart from being significant contributor as slaughter animal for meat production. According to the 19th Livestock Census of Assam, 2012, total bovine population in the state is 113.28 lakhs of which 44.64 lakhs are male and 68.63 lakhs are female. To have an understanding of the dynamics of bovine population in Assam commensurate with the crossbreeding technology diffusion the composition, growth and distribution of bovine population in the state are discussed in detail below.

3.3.1 Composition of Bovine Population

The composition of adult males, adult females and youngstock indicates that over the census periods under consideration there is notable compositional change in the bovine population. The first two census periods in Table 3.10 (1972 and 1982) adult males dominated over adult females in the bovine population. But, after 1982 census, i.e., in 1994, 2003 and 2012 adult females outnumbered the adult males both in absolute and percentage terms. It is evident (from Table 3.10) that in livestock census 1972 share of adult males of bovine population were 39.15 per cent (24.60 lakh) against 31.29 per cent adult females (31.29

lakh). But in 2012 census period share of adult males were 30.63 per cent (32.84 lakh) against 34.40 per cent (36.88 lakh) of adult females, a comparatively much lower share of

Table 3.10: Composition of Bovine Population and Lactating Efficiency of Females in Assam during 1972-2012

Particular	Livestock Population (in Lakh)				Ratio of Cattle to buffalo				Lactating efficiency
	Adult males	Adult Females	Youngstock	Total	Adult males	Adult Females	Youngstock	Total	
Census Year 1972									
1. Cattle	22.60 (39.00)	18.03 (31.11)	17.32 (29.89)	57.95 (100)	11.3	11.06	13.86	11.88	0.51
2. Buffalo	2.00 (40.98)	1.63 (33.40)	1.25 (25.61)	4.88 (100)					0.43
3. Bovine	24.60 (39.15)	19.66 (31.29)	18.57 (29.56)	62.83 (100)					
Census Year 1982[#]									
1. Cattle	21.39 (31.69)	20.65 (30.60)	25.45 (37.71)	67.49 (100)	12.02	11.87	12.41	12.12	0.59
2. Buffalo	1.78 (31.96)	1.74 (31.24)	2.05 (36.80)	5.58 (100)					0.55
3. Bovine	23.17 (31.71)	22.39 (30.65)	27.50 (37.64)	73.06 (100)					
Census Year 1994									
1. Cattle	23.02 (35.49)	25.49 (39.30)	16.35 (25.21)	64.86 (100)	12.05	11.91	11.76	11.92	0.58
2. Buffalo	1.91 (35.11)	2.14 (39.34)	1.39 (25.55)	5.44 (100)					0.62
3. Bovine	24.93 (35.46)	27.63 (39.30)	17.74 (25.23)	70.30 (100)					
Census Year 2003									
1. Cattle	23.33 (34.45)	23.77 (37.94)	18.70 (27.61)	67.73 (100)	12.67	10.75	14.27	12.23	0.56
2. Buffalo	1.84 (33.21)	2.39 (43.14)	1.31 (23.65)	5.54 (100)					0.48
3. Bovine	25.17 (34.35)	28.09 (38.34)	20.01 (27.31)	73.27 (100)					
Census Year 2012[@]									
4. Cattle	31.57 (30.69)	35.31 (34.33)	35.98 (34.98)	102.86 (100)	24.86	22.49	23.83	23.65	0.54
5. Buffalo	1.27 (29.20)	1.57 (36.09)	1.51 (34.71)	4.35 (100)					0.53
6. Bovine	32.84 (30.63)	36.88 (34.40)	37.49 (34.97)	107.21 (100)					

Source: Livestock Census Report of Assam (Various issues)

Notes: 1. Figures in Parentheses are percentages to total. 2. Lactating efficiency is the ratio of females in milk to total adult females, [#]from 1982 onwards cattle population was computed as the sum of crossbred and indigenous cattle, [@] during Livestock Census 2012 the adult cattle population for indigenous breed was considered when the age of the cattle is above 2 years of age against 3 years of age in the previous censuses.

adult males in the bovine population than what it was in 1972 census. This may imply that over the periods under consideration the bovine population have been favoured for milk production purpose rather than what initially was for drought purpose requiring more of

working animal during that time due to relatively less mechanization of agriculture in the state. However, apart from favouring bovine population for milk production and subsequently determining the trend of composition of bovine population the cropping pattern also affects the composition of bovine population. In Kerala, where plantation crops dominate the cropping pattern and where the requirement of draught power in crop production is relatively low, the function of milch cattle has primarily been the production of milk and draught power of male calves becomes secondary (Doornbos and Nair, 1990). Nair and Dhas (1990) also observe that crossbred cattle are primarily valued as dairy animals and hence, from birth to adulthood the sex ratio of this breed will shift in favour of females.¹⁰ On the other hand, since indigenous male cattle breed is preferably valued as draught animals, their sex ratio will shift in favour of males. This may have the implication that with increase in the proportion of crossbred cattle in the total cattle population the herd composition of cattle will shift in favour of female and a reduction in the number of male animal available for draught. Perusal of Table 3.11 and Table 3.12 indicate that in Livestock Census 2012 the proportion of adult crossbred male in total crossbred cattle population is much lower in Assam than what it is for indigenous cattle (8.87 per cent versus 35.66 per cent). On the other hand, the proportion of adult crossbred females in total crossbred cattle population is much higher than the proportion of adult indigenous females in total indigenous cattle population in the same livestock census (69.67 per cent versus 37.90 per cent). The compositional change of crossbred cattle along the livestock censuses is in favour of adult crossbred females where the proportion of adult crossbred female in livestock census 1982 was 55.09 per cent that increased to 69.67 per cent in livestock census 2012. For adult crossbred males, the proportion declined from 13.69 per cent in livestock census 1982 to 8.87 per cent in livestock census 2012 (see Table 3.11). The compositional change of indigenous cattle along the livestock censuses is also in favour of adult females with increasing importance laid on milk production for indigenous breed rather than draught power as there is a declining proportion of adult indigenous males. However, the proportion of adult indigenous males is still higher than what it is for crossbred cattle (see Table 3.12), which imply that there is extensive use of adult indigenous male for draught power even at the recent period. It is further evident from Table 3.10 that almost, one third of the bovine

population is youngstock which are unproductive in the present, a pressure on feed resources but definitely a resource for future as draft power or milch cattle.

Table 3.11: Compositional Change of Crossbred Cattle in Assam

Livestock Census Year	Crossbred Cattle Population (in thousands)			
	Adult Males	Adult Females	Youngstock	Total
1982*	14.34 (13.69)	57.71 (55.09)	32.71 (31.22)	104.77 (100)
1988	16.82 (10.34)	97.59 (60.01)	48.21 (29.65)	162.62 (100)
1994	21.43 (9.88)	131.22 (60.48)	64.30 (29.64)	216.96 (100)
1997	27.88 (11.02)	157.91 (62.45)	67.07 (26.52)	252.85 (100)
2003	27.73 (8.81)	192.62 (61.23)	94.25 (29.96)	314.60 (100)
2012	22.32 (8.87)	175.37 (69.67)	54.02 (21.46)	251.71 (100)

Source: Livestock Census Report of Assam (Various Issues)

Notes: 1. Figures in parentheses indicate percentage to total

* Estimation of crossbred cattle population started from 1982 census only.

Table 3.12: Compositional Change of Indigenous Cattle in Assam

Livestock Census Year	Indigenous Cattle Population (in lakhs)			
	Adult Males	Adult Females	Youngstock	Total
1966	23.67 (38.77)	18.52 (30.34)	18.85 (30.89)	61.04 (100)
1972	22.60 (39.00)	18.03 (31.11)	17.32 (29.89)	57.96 (100)
1979	25.17 (38.85)	19.45 (30.02)	20.17 (31.13)	64.78 (100)
1982	21.25 (32.17)	20.07 (30.39)	24.72 (37.43)	66.05 (100)
1988	25.47 (43.18)	20.78 (35.23)	12.73 (21.59)	58.99 (100)
1994	22.80 (36.88)	24.17 (39.10)	14.85 (24.01)	61.82 (100)
1997	22.62 (36.02)	24.13 (38.42)	16.05 (25.55)	62.80 (100)
2003	23.05 (35.87)	23.77 (36.99)	17.45 (27.14)	64.27 (100)
2012	31.57 (35.66)	33.55 (37.90)	23.40 (26.43)	88.52 (100)

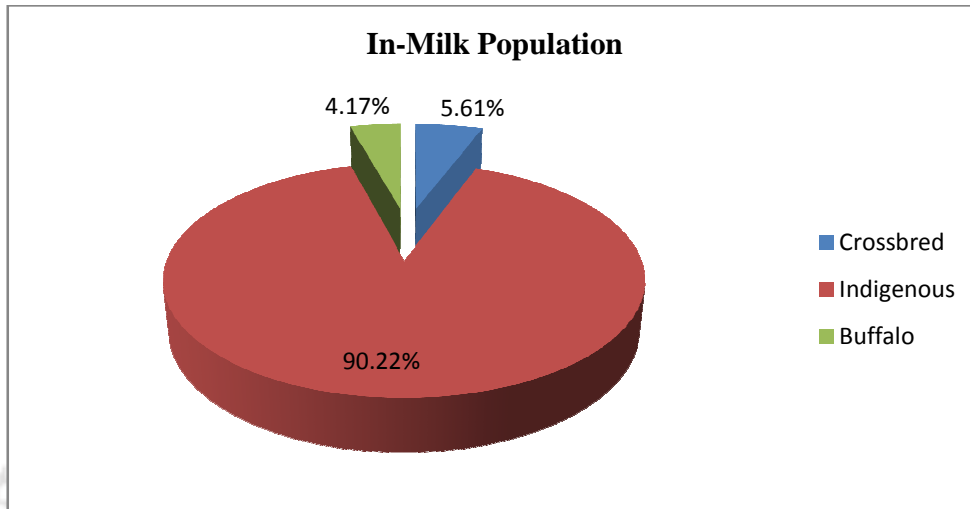
Source: Livestock Census Report of Assam (Various Issues)

Notes: 1. Figures in parentheses indicate percentage to total

Table 3.10 also exhibits that the ratio of cattle to buffalo is remaining almost the same across all previous census periods in the state except the livestock census 2012 where the number of cattle is 12 times higher than the buffalo in the state. As per Livestock Census 2012, ratio of cattle to buffalo for adult males, adult females and young stock are 24.86, 22.49 and 23.83 respectively indicating that during the period from Livestock Census, 2003 to Livestock Census, 2012 the indigenous cattle population increased drastically in the state.¹¹

Moreover, a significant proportion of cattle and buffalo remain dry as more than 40 per cent of the adult females are not in-milk (evident from lactating efficiency).

Figure 3.4: Composition of Bovine Population In-Milk in Assam 2012



Source: 19th Livestock Census of Assam, 2012

According to 19th Livestock Census, 2012 of Assam, the composition of the total in-milk bovine population in the state is that, 90.22 per cent of the in-milk population was of indigenous breed followed by 5.61 per cent and 4.17 per cent are shared by crossbred and buffalo in-milk population (See figure 3.4).

3.3.2 Growth of Bovine Population

The crossbred cattle population increased the highest (7.63 per cent/year) during 1982-94. It was 4.22 per cent/year during 1994-2003 and -1.17 per cent/year during 2003-2012. The corresponding growth rate of in-milk crossbreds during the period under consideration were 8.56, 3.53 and 0.20 per cent. The annual growth rate of youngstock crossbreds during 2003-2012 was 5.19 per cent which registers the highest growth rate among the crossbred components. The growth rate of indigenous cattle was much higher during 2003-2012 (2.89 per cent/year) compared to its previous decades against a negative growth rate of -1.17 per cent/year for crossbred cattle (see Table 3.13). As far the growth in buffalo population is concerned, there is decline of the same across the inter-census periods and the decline is much faster during 2003- 2012 with -4.80 per cent per year. Again, annual growth rate in in-

milk cattle population of indigenous cattle breed is positive and high in all the inter-census periods except a negative growth (-0.57 per cent) during 1994-2003. The growth rate of crossbred male population has declined rapidly from an annual growth rate of more than 4 per cent per year in 1982-1994 to -2.38 per cent per year during 2003-2012 which implies that due to lower drought capacity of crossbred male, there is increasingly lesser preference given to crossbred male cattle by the cattle keepers (also see Table 3.11 and Table 3.12). It is evident from Table 3.13 that although there has been massive effort undertaken for improving the cattle stock of the state after formation of ALDA in 2004 and NPCBB taking the lead role in sponsoring cattle breed improvement programme in Assam, the annual

Table 3.13: Compound Annual Growth Rate of Bovines in Assam (During 1972-2012)

Particulars	Period			
	1972-1982	1982-1994	1994-2003	2003-2012
Cattle				
A. Crossbred*				
Male over 2.5 years	-	4.10	2.90	-2.38
Female over 2.5 years				
1. In Milk	-	8.56	3.53	0.20
2. Dry	-	8.59	4.01	-0.94
3. Not calved even once	-	6.94	6.40	-4.71
Young stock	-	1.65	4.25	5.19
Total Crossbred	-	7.63	4.22	-1.17
B. Indigenous				
Male over 3 years	-0.62	0.59	0.12	3.56
Female over 3 years				
1. In Milk	2.42	1.35	-0.57	3.53
2. Dry	1.23	0.20	0.21	5.02
3. Not calved even once	1.36	5.89	-1.79	5.36
Young stock	3.62	-4.16	1.81	3.32
Total Indigenous	1.31	1.40	0.25	2.89
Buffalo				
Male over 3 years	-1.15	0.58	-0.40	-4.03
Female over 3 years				
1. In Milk	3.24	2.82	-2.32	-3.46
2. Dry	1.10	-2.32	3.31	-2.84
3. Not calved even once	-1.11	8.47	-2.99	-2.76
Young stock	5.07	-3.17	-0.69	-2.26
Total Buffalo	1.33	1.31	0.43	-4.80

Source: Livestock Census Report of Assam (Various issues)

Notes: * The national and state level enumeration of crossbred cattle population started from Livestock census, 1982 onwards only.

growth rate of crossbred cattle during 2003-2012 has been very unimpressive. This point out the necessity of emphasizing on identification of determinants of adoption/rejection of the crossbreeding technology and the underlying constraints perceived for adoption of crossbreeding technology at farmer's level in the state.

3.3.3 Distribution of Bovine Population

The district-wise distribution of bovines is shown in Table 3.14. It is found that out of the total bovine population, indigenous cattle population shares the highest across the districts (around 90 per cent). Proportion of adult males of indigenous breed in the state is above 20 per cent and same is the highest in Bongaigaon district (more than 22 per cent) and lowest is in Dhubri district (15.43 per cent). Again the proportion of in milk cattle population for indigenous breed hovers around 11 per cent (highest in Nalbari district and lowest in Jorhat district). The proportion of crossbred cattle population to bovine population in Assam is just 4 per cent in which districts like Kamrup (10 per cent), Jorhat (8.6 per cent) and Barpeta (6.2 per cent) exhibits relatively higher proportion. Districts such as Lakhimpur (1.91 per cent), Dhemaji (1.2 per cent) and Kokrajhar (2 per cent) where diffusion of Artificial Insemination (AI) is relatively cumbersome for being flood prone or conflict ridden district in the state, have the lowest share of crossbred cattle population. The share of buffalo population is relatively more in the hill districts (Karbi Anglong and NC Hills) and in Hailakandi and lowest in Baksa district .

Table 3.14: District-wise Composition and Distribution of Bovines in Assam (TE 2012-13)

Particulars	Goalpara	Dhubri	Kokrajhar	Bongaigaon	Barpeta	Nalbari	Baska	Kamrup	Darrang	Udalguri	Sonitpur	Lakhimpur	Dhemaji	Morigaon
Total cattle (Indigenous)	92.19	91.52	92.96	91.47	89.38	91.39	95.09	86.35	89.92	92.77	91.57	93.54	93.53	91.22
Male > 3 Years	21.60	15.43	21.57	22.24	20.33	20.88	21.11	20.00	20.08	21.27	20.59	20.30	21.08	21.12
Cattle in milk	11.47	11.19	11.25	11.94	10.82	11.66	9.95	10.86	10.55	10.93	11.28	11.01	11.80	11.50
Dry	8.50	7.26	7.91	7.91	7.83	6.88	8.89	7.63	6.60	8.82	8.21	8.55	9.31	7.50
Not calved yet	2.21	1.98	2.21	2.35	2.38	2.09	2.18	2.16	1.86	2.46	1.85	2.40	2.26	2.25
Young Stock	32.74	37.78	30.57	29.85	30.47	32.13	31.52	29.09	33.55	29.96	32.24	33.63	33.45	30.25
Total cattle (Crossbred)	2.73	2.58	2.00	4.49	6.24	5.11	2.44	10.04	5.42	2.83	3.52	1.91	1.20	4.80
Male > 3 Years	0.30	0.30	0.20	0.49	0.59	0.64	0.25	0.99	0.56	0.30	0.38	0.24	0.13	0.49
Cattle in milk	0.96	0.90	0.65	1.57	2.15	1.75	0.84	3.22	1.78	1.02	1.18	0.76	0.44	1.79
Dry	0.39	0.38	0.32	0.61	0.87	0.73	0.33	1.47	0.78	0.39	0.46	0.30	0.18	0.69
Not calved yet	0.08	0.08	0.07	0.14	0.19	0.18	0.21	0.37	0.16	0.12	0.12	0.07	0.05	0.16
Young Stock	1.01	0.92	0.76	1.68	2.43	1.81	0.81	4.00	2.13	1.00	1.38	0.55	0.40	1.66
Total Buffaloes	5.08	5.90	5.04	4.04	4.38	3.50	2.47	3.61	4.66	4.40	4.91	4.55	5.27	3.98
Total bovines in Lakh to which percentages have been worked out	3.47	5.65	4.73	4.12	5.41	3.74	2.69	6.06	5.31	2.93	6.89	4.95	4.55	3.38

Particulars	Nagon	Golaghat	Jorhat	Sibsagar	Dibrugarh	Tinsukia	Karbi Anglong	NC Hills	Karimganj	Hailakandi	Cachar	Assam Total
Total cattle (Indigenous)	90.39	92.80	86.96	92.67	91.25	93.20	90.79	87.81	91.29	89.78	91.77	91.21
Male > 3 Years	20.96	21.43	17.78	20.67	20.22	21.27	20.29	20.20	20.22	19.67	19.55	20.31
Cattle in milk	10.99	11.09	9.42	11.57	11.11	10.55	11.73	10.76	10.54	9.65	10.15	10.99
Dry	7.75	7.92	7.24	7.66	8.57	8.11	8.37	7.65	7.93	7.26	6.87	7.87
Not calved yet	1.91	2.28	2.00	2.18	2.30	2.12	2.15	2.46	1.99	2.65	2.04	2.16
Young Stock	31.39	31.96	31.10	31.75	31.02	32.69	34.18	35.69	32.94	29.71	33.33	32.20
Total cattle (Crossbred)	4.72	2.99	8.60	3.18	4.11	2.74	3.12	3.54	3.07	3.65	3.29	4.04
Male > 3 Years	0.52	0.32	0.78	0.38	0.45	0.28	0.34	0.37	0.30	0.43	0.35	0.42
Cattle in milk	1.57	1.10	2.79	1.13	1.43	1.04	1.13	1.12	0.99	1.18	1.05	1.38
Dry	0.67	0.50	1.08	0.45	0.58	0.44	0.38	0.56	0.41	0.46	0.41	0.57
Not calved yet	0.17	0.10	0.25	0.11	0.12	0.09	0.11	0.11	0.11	0.13	0.13	0.14
Young Stock	1.78	0.98	3.68	1.11	1.53	0.89	1.16	1.37	1.26	1.45	1.36	1.53
Total Buffaloes	4.90	4.20	4.44	4.15	4.64	4.07	6.09	8.65	5.64	6.57	4.94	4.75
Total bovines in Lakh to which percentages have been worked out	5.81	5.37	4.83	4.57	5.39	5.41	6.60	2.00	4.40	2.11	5.69	116.07

Source: Integrated Sample Survey Reports, Various issues, Directorate of Animal Husbandry and Veterinary, Govt. of Assam.

As far as cattle density is concerned, on an average, per hundred hectare of geographical area in Assam accommodates 132 cattle, comprising 9 crossbred and 123 indigenous cattle. The corresponding figure for grazing area is 319 (22 crossbreds and 297 indigenous cattle). Udalguri district (238) has the highest cattle density per hundred hectare of geographical area followed by Lakhimpur district (225) whereas NC Hills (8) has the lowest cattle density per 100 hectare of geographical area (see Table 3.15). As far density per 100 hectare of grazing area is concerned Nagaon district has 971 cattle followed by Udalguri district (885) and lowest being 10 cattle in NC Hills. The density of crossbred cattle per 100 hectare of geographical area is the highest in

Table 3.15: District-wise Density of Bovines in Assam (2007)

District	Geographical Area (in ha)	Grazing Area (in ha)	Density/100 ha of Geographical Area				Density / 100 ha of Grazing Area [@]			
			Crossbred	Indigenous	Total Cattle	Buffalo	Crossbred	Indigenous	Total Cattle	Buffalo
Goalpara	182400	73826	2.33	123.89	126.23	4.57	5.77	306.1	311.9	11.3
Dhubri	166410	103097	7.08	284.03	291.11	15.49	11.42	458.5	469.9	25
Kokrajhar	316544	65149	0.44	130.82	131.26	6.10	2.13	635.6	637.8	29.1
Bongaigaon	172529	84320	9.58	132.55	142.13	1.54	19.60	271.2	290.8	3.2
Barpeta	267733	57186	19.54	156.18	175.72	5.73	91.49	731.2	822.7	26.8
Nalbari	100957	32753	24.90	195.28	220.18	4.66	76.7	601.9	678.7	14.4
Baska	200750	47004	6.34	161.26	167.60	1.49	27.1	688.7	715.8	6.4
Kamrup	411095	110105	33.25	131.02	164.27	1.73	124.1	489.2	613.3	6.5
Darrang	185058	76598	6.86	152.53	159.39	8.37	16.6	368.5	385.1	20.2
Udalguri	167394	45044	7.76	230.25	238.01	3.16	28.8	855.7	884.5	11.8
Sonitpur	528058	219314	4.54	133.91	138.46	3.80	10.9	322.4	333.4	9.2
Lakhimpur	227700	105476	3.33	221.62	224.95	6.60	7.2	478.4	485.6	14.2
Dhemaji	323700	196839	0.04	133.39	133.43	3.09	0.1	219.4	219.4	5.1
Morigaon	155100	53547	16.42	184.71	201.13	9.20	47.6	535	582.6	26.7
Nagaon	397300	87380	14.28	199.20	213.48	3.11	64.9	905.7	970.7	14.1
Golaghat	350200	78119	7.18	125.34	132.52	7.86	32.2	561.9	594.1	35.2
Jorhat	285100	142956	13.98	164.24	178.22	10.91	27.9	327.5	355.4	21.8
Sibsagar	266800	93003	7.10	147.83	154.93	9.53	20.4	424.1	444.5	27.3
Dibrugarh	338100	175943	19.14	134.54	153.68	7.29	36.8	258.5	295.3	14
Tinsukia	379000	142691	7.02	77.73	84.75	6.22	18.6	206.5	225.1	16.5
Karbi	1043400	587707	2.80	35.58	38.38	1.42	5	63.2	68.1	2.5
Anglong										
NC Hills	488800	393352	2.59	5.67	8.26	6.81	3.2	7	10.3	8.5
Karimganj	180900	48870	9.34	160.4	169.74	26.83	34.6	593.8	628.3	99.3
Hailakandi	132700	19873	21.56	92.59	114.15	26.35	144	618.2	762.2	176
Cachar	378600	123815	5.48	87.99	93.47	17.44	16.8	269.1	285.8	53.3
Assam Total	7646328	3163967	8.94	122.99	131.94	6.65	21.6	297.2	318.8	16.1

Source: Land Utilisation Statistic, 2013, Directorate of Economics & Statistics, Govt. of Assam, Livestock Census of Assam, 2007.

[@]Grazing Area include permanent pastures and other grazing land, land under miscellaneous tree crops, uncultivable land and other fallow lands.

Kamrup district (33) and the lowest in Dhemaji district (0.04). Again, the corresponding figure for grazing area is 124 in Kamrup and 0.1 in Dhemaji. The high crossbred cattle density in Kamrup district is due to the large concentration of commercial dairy farm reared mostly by the Nepali and Bihari communities in the peri-urban parts of Guwahati city. The low density in Dhemaji district is due to the lowest coverage of breedable cattle population because the AI service in the district is negatively influenced by the recurrent flood. Districts like Karimganj and Hailakandi have higher buffalo density than the rest of the districts. From Table 3.15, it is found that there are variations of cattle and buffalo density among the districts. Many of the districts have lower density implying the higher potentiality of breed improvement in those districts compared to carrying capacity of the district.

If comparison is made in the performance of Assam in achieving breed improvement with that of other states in the country, it has a very negligible share of crossbred cattle population. Some of the southern states such as Kerala (79 per cent) and Tamil Nadu (39 per cent) and states and UTs in the North like Punjab (69 per cent), Chandigarh (86 per cent), Delhi (63 per cent), Haryana (35 per cent) and Jammu and Kashmir (34 per cent) are performing relatively much better in the breed improvement programme (See Table 3.16).

Table 3.16: Classification of States According to Percentage Share of Crossbreds in Total Cattle Population (1997)

Share of crossbreds	States
Less than 10 per cent	Andhra Pradesh (7.1), Arunachal Pradesh (2.4), Assam (4.6), Bihar (0.9), Chhattisgarh (1.2), Goa (8.0), Gujarat (5.1), Madhya Pradesh (0.9), Meghalaya (2.3), Orissa (6.6), Rajasthan (1.7), Tripura (5.9), Uttaranchal (5.1), West Bengal (5.2), Dadra and Nagar Haveli (1.7), Daman and Diu (0), All-India (10.1)
10-25 per cent	Himachal Pradesh (16.9), Karnataka (11.9), Maharashtra (13.6), Mizoram (23.5), Uttar Pradesh (10.5), Andaman and Nicobar Island (10.0), Pondicherry (10.1), Lakshadweep (25.0)
25-40 per cent	Haryana (35.3), Jammu and Kashmir (34.1), Sikkim (36.4), Tamil Nadu (38.8)
Above 40 per cent	Kerala (78.6), Nagaland (40.1), Punjab (69.3), Chandigarh (85.7), Delhi (62.5)

Source: Sharma (2004)

3.4. Crossbreeding and Milk Production Dynamics

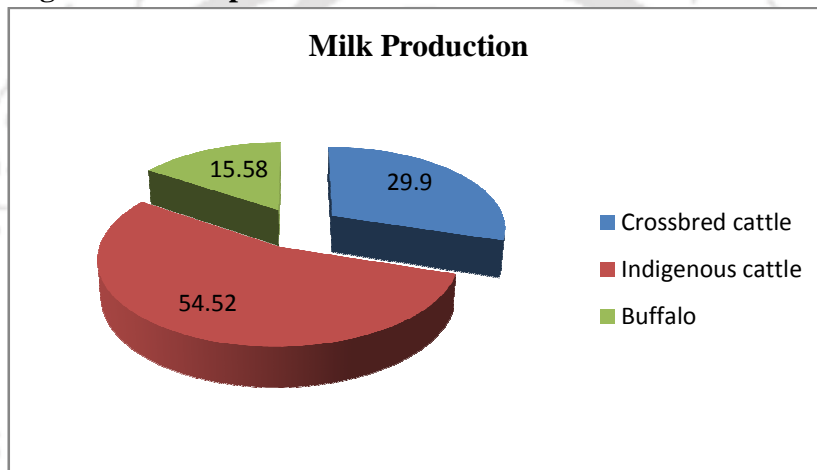
3.4.1. Trend in Bovine Milk Production and Productivity in Assam

Assam has a bovine milk production of 826.213 million litres during 2012-13 of which crossbred and indigenous cattle milk shares 29.90 per cent and 54.52 per cent respectively and the rest

comes from buffalo milk (see Figure 3.5). The increase in indigenous cattle milk production in the state is not remarkable due to a relatively constant yield rate over the years (see Table 3.18).

The crossbred cattle that constitutes a negligible proportion (3.84 per cent according to Livestock Census, 2012) in the total cattle population contributes a higher proportion in total cattle milk production (35.42 per cent) in the state. This has been possible due to higher milk yield of crossbred cattle relative to indigenous breed. Again, the milk production by crossbred cattle has experienced overtime a higher growth rate in Assam (see Table 3.17).

Figure 3.5: Composition of Bovine Milk Production in Assam



Source: Integrated Sample Survey Report, 2012,

The average annual growth rate in the crossbred cattle milk production was 5.46 per cent during 1986-87 to 2012-13, a relatively much higher growth in crossbred cattle milk production over the milk production by indigenous breed (0.56 per cent). The growth in buffalo milk production in the period under consideration is relatively higher than the milk production by indigenous breed. The negative growth in indigenous cattle milk production during 2006-07 to 2012-13 and relatively a much higher growth in crossbred cattle milk production during the same period may have the implication that during this period, under the support of NPCBB, initiatives undertaken

Table 3.17: Trend in Bovine Milk Production in Assam

Particulars	Production (million litres)				Annual Growth (%)			
	1986-87	1997-98	2006-07	2012-13	1986-87 to 1997-98	1997-98 to 2006-07	2006-07 to 2012-13	1986-87 to 2012-13
Cattle								
Indigenous	389	463	511	450	1.60	1.10	-2.10	0.56
Crossbred	62	133	179	247	7.18	3.36	5.51	5.46
Buffalo	72	96	105	129	2.65	1.00	3.49	2.27
Total	523	692	795	826	2.58	1.55	0.64	1.77

Source: *Integrated Sample Survey Reports, Various issues*, Directorate of Animal Husbandry and Veterinary, Govt. of Assam.

by ALDA could change the genetic makeup of some of the non descript cattle through Artificial Insemination (AI) and made them crossbred. Thus milk production by indigenous breed decelerated and there was a higher growth in crossbred cattle milk production.

Table 3.18: Trend in Bovine Milk Productivity in Assam (litres/in milk animal/annum)

Particulars	1986-87	2006-07	2012-13
Cattle			
Indigenous	358	390	367
Crossbred	1378	1383	1559
Buffalo	691	786	1097

Source: *Integrated Sample Survey Reports, Various issues*, Directorate of Animal Husbandry and Veterinary, Govt. of Assam.

Table 3.18 presents the growth trend in bovine milk productivity per annum in Assam from 1986-87 to 2012-13. It reveals that there has not been any significant increase in the milk productivity of indigenous cattle in the state during the period under consideration. In case of per annum milk productivity of crossbred cattle Table 3.18 reveals that there has not been any significant increase in milk productivity of crossbreds from 1986-87 to 2006-07 but from 2006-07 to 2012-13 there is a steep rise in milk productivity of crossbred cattle (from 1383 litres to 1559 litres) implicating that during this period the quality traits of exotic germ plasm used in the local cattle introduced by ALDA under NPCBB is significantly of high yielding nature (due to induction of exotic pure-breed bull) compared to the quality traits of exotic germ plasm used in indigenous cattle in the previous periods. The buffalo milk productivity is also increasing rapidly during the same period and the reason behind the increase of buffalo milk productivity in the state, as reported by the officials of ALDA, that during the recent period a massive induction of

riverine buffalo population had taken place in the state along with crossbreeding of indigenous swamp buffalo with Murrah during the last two years.

3.4.2 Cattle Crossbreeding and Milk Production Linkage

The comparison in the yield level between crossbred and indigenous cattle across districts in the state exhibits a marked difference between the two. Average productivity of crossbred cattle of Assam is 4.27 litres/day/cattle in the state whereas the productivity of indigenous cattle is 1.01 litre/day/cattle. Average productivity of crossbred cattle is the highest in Dhubri district (4.45 litres/day/cattle), whereas it is lowest in Karbi Anglong district (4.04 litres/day/cattle). Again, as far productivity of indigenous breed is concerned it is the highest in Barpeta district

Table 3.19: Average Productivity (litre/day/cattle) of Crossbred and Indigenous Cattle across Districts of Assam (2012-13)

Districts	Crossbred	Indigenous	% gain in Yield
Goalpara	4.05	1.00	305
Dhubri	4.45	1.01	342
Kokrajhar	4.25	0.98	334
Bongaigaon	4.40	1.13	288
Barpeta	4.19	1.17	259
Nalbari	4.18	0.99	321
Baska	4.30	1.02	323
Kamrup	4.25	1.14	272
Darrang	4.31	0.93	363
Udalguri	4.21	0.96	339
Sonitpur	4.16	0.95	338
Lakhimpur	4.31	0.98	341
Dhemaji	4.32	1.03	318
Morigaon	4.32	1.01	329
Nagaon	4.25	1.03	313
Golaghat	4.33	0.98	340
Jorhat	4.32	0.98	339
Sibsagar	4.14	0.99	318
Dibrugarh	4.36	0.98	341
Tinsukia	4.22	1.00	322
Karbi Anglong	4.04	0.95	328
N.C. Hills	4.41	0.87	407
Karimganj	4.36	0.97	351
Hailakandi	4.34	1.03	320
Cachar	4.24	0.97	339
Assam	4.27 (0.0243)	1.01 (0.0647)	324 (0.0877)

Source: Integrated Sample Survey Report 2012-13, Directorate of Animal Husbandry and Veterinary, Govt. of Assam. **Note:** Figures in parentheses indicate coefficient of variation (CV)

(1.17 litres/day/cattle) and lowest in Karbi Anglong district (0.87 litres/day/cattle). The percentage gain in yield of crossbred cattle over indigenous breed is 324 per cent in Assam with

highest being in Karbi Anglong district (402 per cent) due to higher milk yield differences between the two breeds (see Table 3.19). Although there is significant productivity differences across breeds in the state but for both the cattle breeds there is not much productivity differences across districts. The increase in milk yield from new technology, i.e., rearing of crossbred cattle is very significant and likely to give higher returns over the old technology, i.e., rearing of indigenous cattle. In a study by Kumar (2001) conducted in Meerut district of Uttar Pradesh it was found that the contribution of technological change (indigenous breed to crossbred) was 47.65 per cent.

Perusal of Table 3.20 indicates the role of crossbreeding of cattle in the increase of milk production in the state. Kumar et al (2003) estimated effect of crossbreeding on milk production across various states in India through extrapolation of the population and milk production data. The present study makes an attempt to analyze the same across the districts of Assam. Assuming that there is zero crossbreeding in the state then the hypothesized (expected) total milk production comes out to be 5086 lakh litres and after considering the increase in milk production due to crossbreeding then the state has actual milk production of 6975 lakh litres with an increase of 1889 lakh litres (37 per cent increase due to crossbreeding)¹². The highest absolute increase in milk due to crossbreeding at district level is witnessed in Kamrup district (242.58 lakh litres) followed by Jorahat (160.72 lakh litres) and Barpeta district (125.76 lakh litres). However, in terms of percentage gain due to crossbreeding Jorhat district exhibits highest gain (74 per cent) followed by Kamrup (64 per cent) and Darrang district (53 per cent). The districts that reflect percentage gain due to crossbreeding above the state average of 37 per cent are Barpeta, Nalbari, Kamrup, Darrang, Morigaon, Nagaon, Jorhat, Dibrugarh, NC Hills and Hailakandi.

Table 3.20: Increase in Cattle milk production due to crossbreeding in Assam

Districts	Milk Production (in litre)			
	Estimated assuming zero crossbreeding (in lakh)	Actual (in lakh)	Net Increase (in lakh)	%age increase
Goalpara	146.55	177.83	31.28	21
Dhubri	250.40	313.31	62.91	25
Kokrajhar	214.73	244.25	29.51	13
Bongaigaon	241.93	317.11	75.17	31
Barpeta	289.15	414.91	125.76	43
Nalbari	174.29	250.23	75.93	44
Baska	111.71	137.65	25.94	23
Kamrup	379.12	621.70	242.58	64
Darrang	195.61	300.26	104.64	53
Udalguri	128.51	159.57	31.06	24
Sonitpur	297.34	389.65	92.30	31
Lakhimpur	186.22	233.08	46.85	25
Dhemaji	165.66	191.52	25.85	16
Morigaon	170.99	245.83	74.83	44
Nagaon	270.32	375.21	104.88	39
Golaghat	224.85	296.74	71.88	32
Jorhat	217.28	378.01	160.72	74
Sibsagar	206.19	270.31	64.11	31
Dibrugarh	241.40	330.06	88.66	37
Tinsukia	209.52	277.69	68.17	33
Karbi				31
Anglong	258.70	338.88	80.18	
N.C. Hills	58.37	88.48	30.10	52
Karimganj	152.11	205.68	53.56	35
Hailakandi	82.91	121.76	38.84	47
Cachar	221.17	295.09	73.92	33
Assam	5086.00	6974.91	1888.90	37

Source: Author's estimation from the *Report of Integrated Sample Survey, 2012-13*, Govt. of Assam

Table 3.21 represents the percentage contribution of indigenous, crossbred and buffalo milk to the increase in total milk production. The contribution of indigenous cattle milk to the increase in bovine milk production was 20.36 per cent while the same estimate for crossbred cattle showed 61 per cent and of buffalo was 18.67 per cent during 1987 to 2012. It is evident from Table 3.21 that there has been a marked structural transformation in the composition of bovine milk in the state during the period under consideration. During the decade of 1987-1998, contribution of crossbred cattle in the increase in total milk production was less (42%) than what it was for indigenous cattle (43.94%). But during 2007-2012, the contribution of crossbred cattle increased to a remarkably higher proportion of 216.51 per cent and that for indigenous breed a significantly

declining proportion of -193.42 per cent. It can be inferred that if sufficient importance is laid on the diffusion of high yielding CB cattle in the state of Assam, there is higher potentiality of improving the milk production scenario in the state.

Table 3.21: Contribution of cattle (Indigenous and Crossbred) and buffalo to the increase in milk production in Assam during 1987 to 2012

Year	Increase in total Milk Production (%)			
	Cattle		Buffalo	Total
	Indigenous	Crossbred		
1987-1998	43.94	41.92	14.15	100
1998-2007	46.60	44.99	8.41	100
2007-2012	-193.42	216.51	76.90	100
1987-2012	20.36	60.97	18.67	100

Source: *Integrated Sample Survey Reports, Various issues*, Directorate of Animal Husbandry and Veterinary, Govt. of Assam.

3.4.3. Decomposition of the Factors Contributing to the Growth of Milk Production

In the context of studying the influence of technological change in the growth of milk production in the state of Assam understanding the relative contribution of milch bovine population or productivity or the both is important. The additive decomposition model developed by Minhas and Vaidyanathan (1965) which was used in the growth of crop output has been used to analyze the relative contribution of these factors to the growth in total milk production in the state. The model has the following form:

$$M_T - M_B = (P_T - P_B)Y_B + (Y_T - Y_B)P_B + (P_T - P_B)(Y_T - Y_B) \quad (3.1)$$

Where,

M = Total milk production of cattle/buffalo

P = In-milk population

Y = Average annual milk yield of in-milk population

Subscripts, T and B refers to the terminal and base year respectively

The left-hand side of the equation 3.1 denotes the growth in milk production of the state whereas the right-hand side of it has three parts. The first part is the growth in in-milk population of the species remaining the average milk yield unchanged and considered as ‘population effect’. The second part, on the other hand, is the growth in average annual yield level remaining growth in

in-milk population as unchanged and this is termed as ‘yield effect’. The third part considers together the changes in population and yield level and termed as ‘interaction effect’. The results are given in Table 3.22. The result of the decomposition model is presented in Table 3.22. Perusal of the table indicates that with the passage of time productivity has played an important role in the growth of bovine milk production in the state. During the period under consideration yield effect is dominant (57 per cent) in the growth of bovine milk production in the state. The same holds true for both cattle and buffalo milk with the share of yield effect to the tune of 56.94 per cent and 55.68 per cent respectively during 1986-87 to 2006-07. During the decade of 1986-87 to 1997-98 population effect had dominant role (67.5 per cent contribution) which eventually during 1997-98 to 2006-07 became negative (-24.5 per cent). The yield effect in the growth of bovine milk rose from 27 per cent during 1986-87 to 1997-98 to 129 per cent during 1997-98 to 2006-07. From Table 3.22, it is summarized that bovine milk production has increased in Assam due to the rise in productivity as there is increased share of high yielding crossbred cattle in the recent period in Assam. The finding is consistent with the finding of the study carried out by Dhas (2001) in Tamil Nadu. In case of buffalo with stronger yield effect during 1997-98 to 2006-07 compared to a negative yield effect in the previous decade may be attributed to the massive induction of high yielding riverine buffalo breeds of Murrah and surti during the last decade (as per the observation of senior officials of ALDA)

Table 3.22: Relative Contribution of different Factors to the Growth of milk Production in Assam (in per cent)

Output	Sources of Contribution	1986-87 to 1997-98	1997-98 to 2006-07	1986-87 to 2006-07
Bovine Milk	Population effect	67.49	-24.56	33.44
	Yield effect	27.30	129.29	57.08
	Interaction effect	5.98	-4.72	9.96
Cattle Milk	Population effect	64.58	-17.00	33.06
	Yield effect	29.32	120.23	56.94
	Interaction effect	6.10	3.23	10.01
Buffalo Milk	Population effect	106.25	-158.17	35.40
	Yield effect	-4.62	301.08	55.68
	Interaction effect	1.63	-42.93	8.92

3.5 Summing up

Changes in breeding policy to adjust with local condition and farmer's needs and expansion of infrastructure related to crossbreeding since 1976 has resulted in gradual increase in the proportion of crossbred cattle in total cattle population in Assam. However, this increase is very nominal in comparison to the number of years since organized efforts were first made on crossbreeding programme in the state. It is found that crossbred cattle population significantly contributes to the overall milk production in the state. In 2012-13, share of crossbred cattle milk production in total bovine milk production was 30 per cent against a meager proportion of crossbred cattle in total bovine population of 3.87 per cent. This is largely because of higher milk yield of crossbred cattle that has resulted in 37 per cent increase in milk production in Assam due to crossbreeding of cattle. Although during the decade, 2003-2012 the proportion of crossbred cattle population has not increased significantly even though ALDA took major initiatives under the support of NPCBB to intensify the activities for crossbreeding, the share of crossbred cattle milk production in the state during this period was increasing at a sustained rate which was possible due to increase in yield rate. The increase in yield rate may be due to induction of Jersey and HF bulls of high genetic merit for quality semen production purpose by ALDA from CCBF, Sunabeda and Hessarghatta respectively. Thus, on one hand, increase in share of crossbred cattle milk due to rise in yield and relatively stable proportion of crossbred cattle population during the post ALDA formation period, on the other hand may imply that the quality of exotic semen used in local cattle has increased in the state but the adoption rate of crossbreeding programme at farmer's level has not increased in Assam. This puts a question mark on the extension effort and also indicates the lack of available study to demonstrate the farmers' wellbeing impact after adoption of crossbreeding technology. This calls for impact study of crossbreeding technology adoption on farmer's economy in Assam and identification of factors leading to adoption of the breeding technology such as Artificial Insemination. The secondary data on factors determining adoption and welfare impact of crossbreeding technology adoption on farmer's economy in Assam is unavailable. So, based on cross-sectional data of dairy farmers in Assam efforts are made in the subsequent chapters to understand the various issues related to production and productivity, farmer's wellbeing impact after adoption of crossbreeding technology and identification of factors that influence adoption and extent of adoption of crossbreeding technology among farmers in Assam.

Notes:

1. Overall returns (from changes of technical and inputs together) from the crossbred cow was nearly 157 per cent higher than that of the local cow, where contribution of technological change turned out to be 47.65 per cent whereas the contribution of input use difference was as high as 109.15 per cent (Kumar, 2001)
2. The guidelines of the government of India to State Directorates of Animal Husbandry, in the fourth plan was selection of one breed with a view to ensuring continuity and economy in breeding operations and precautions about the maintenance of crossbreed stock (Singh, 1986)
3. Although in the North East India context, not much experiment is done in the crossing of swamp x murrah, but in countries like China, Philippines and in other South East Asian countries, such crossbreeding programme was carried out much before. In fact, China imported murrah buffaloes from India in late 1950 and since then, large number of crossbreds has been produced with remarkable results in milk production and size of the animals.
4. A National Seminar on Improvement of Swamp Buffaloes of North Eastern Region of India was held on February 11, 2005, at Assam Administrative Staff College, Guwahati, organized by Assam Livestock Development Agency (ALDA) and sponsored by Govt. of India (NPCBB).
5. One semen ejaculation from a bull can be used to serve 400 to 500 animals through AI and therefore, one bull can produce sufficient semen to cover about 5,000 cows per year (see Peera, 1999) which means that the bulls with top most germ plasm in the world can be selected and used on cows and buffaloes which are widely separated in space and time (Sasidhar et al., 2004).
6. 300 Fertility Camps and 100 Farmers orientation camps have been organized in the state under NPCBB phase I for benefit of the farming community where apart from reproductive cases treatment and vaccination and de-worming was done. These camps act as a platform for introduction of new Gopal Mitras (Private AI workers) trained under the 1st phase of NPCBB. In NPCBB phase II, 1200 new fertility camps are being organized under Phase-II under which TV documentary and Radio Jingles are being broadcasted to popularize AI (Monitoring Cell, Assam Livestock Development Agency)
7. The selection criterion of the *Gopal Mitras* are that a) they should be VIII to X standard passed, b) They should have knowledge on cattle breeding, c) his residence should be 5 km away from government dispensary, and d) the area where the *Gopal Mitra* will practise should essentially have more than 1000 cattle.
8. In most of the states the semen is dispatched to the insemination units on every alternate day in UP, Delhi and in some AI centres of a few other states, semen is dispatched to the insemination centres only twice a week or even at longer intervals and consequently the quality of semen used at village level in such places may not be good enough for obtaining a satisfactory conception rate (National Commission on Agriculture, 1976). Therefore, ideally it should be dispatched daily or every alternate days.

9. The current statistics at all India level indicate that a stockman per AI centre on an average doses 530 inseminations in a year. The same stockman in mobile AI unit can easily perform 10,000 AI in a year which comes out to be 800 AI per month and about 27 AI per day (Sasidhar et al., 2004).

10. Sasidhar et al. (2004) also observes that because of less care being taken for crossbred male calves, few calves would grow in to bulls and majority of them get vanished due to negligence of farmer since the day it was born.

11. The increase in livestock population in Assam were much higher having the third position among the states in India with 24.9 and 10.77 per cent during 18th (2003-07) and 19th (2007-2012) Livestock Census.

12. Through state-wise comparison of milk production figures between assumed with zero crossbreeding and actual Kumar et al. (2003) found that crossbreeding of cattle increased the cattle milk production in the country by 35 per cent; whereas in Assam it was 20 per cent.



APPENDIX - 3

Table A3.1: Milk Utilization Pattern in Assam (1986-87 to 2012-13)

Year	Milk Utilization (in Per cent)		
	Milk Sold as Liquid	Milk Consumed as Liquid	Converted into Milk Products
1986-87	14.90	44.17	40.93
1999-00	15.80	48.30	35.90
2006-07	18.20	46.30	35.50
2009-10	30.00	48.00	22.00
2012-13	42.00	36.00	22.00

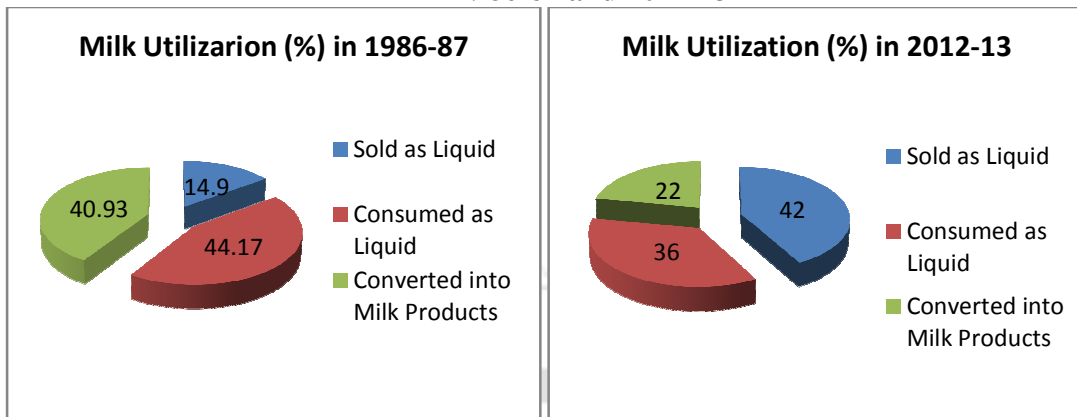
Source: Integrated Sample Survey Report (Various issues), Govt. of Assam,

Table A3.2: Performance of buffaloes in Assam

Trait	Genetic Group/Breed		
	Swamp	Murrah	Surti
Age at 1 st calving (months)	59.03 ± 0.42	53.88 ± 0.48	51.52 ± 1.18
First lactation milk yield (kg)	509.63 ± 4.20	1057.89 ± 17.94	843.34 ± 5.01
First lactation length (days)	282.87 ± 78	280.23 ± 3.50	300.36 ± 1.87
1 st lactation peak yield (kg)	4.09 ± 0.04	6.11 ± 0.07	4.54 ± 0.04
Days to attain 1 st peak yield	58.28 ± 0.93	49.25 ± 1.24	56.80 ± 0.64
Persistency of 1 st lactation	0.88 ± 0.01	0.93 ± 0.02	0.93 ± 0.01
Lactation milk yield (kg)	505.95 ± 3.14	1186.31 ± 18.46	988.14 ± 21.71
Lactation length (days)	283.43 ± 1.44	287.29 ± 4.38	313.60 ± 6.17
Peak yield (kg)	4.08 ± 0.03	8.39 ± 0.82	6.07 ± 0.06
Days to attain peak yield	57.89 ± 0.68	51.06 ± 0.73	60.02 ± 0.83
Dry period (days)	224.58 ± 2.17	204.11 ± 7.17	318.02 ± 16.48
Service period (days)	181.75 ± 2.39	170.56 ± 7.04	336.91 ± 16.50
Gestation Period (days)	325.85	-	-
Inter-calving period (days)	507.80 ± 2.39	479.54 ± 7.08	636.70 ± 16.49
Milk			
Specific gravity	1.0296 ± 0.0002	-	-
Fat %	8.478 ± 0.069	-	-
S.N.F %	9.910 ± 0.039	-	-
Total solids %	17.675 ± 0.088	-	-

Source: Das (2005)

Figure A3.1: Comparison of Milk Utilization (in %) in Assam between the period 1986-87 and 2012-13



Source: Table A3.1



CHAPTER FOUR

FIELD STUDY LOCATION, SAMPLE AND SAMPLE PROFILE

4.1. The Purpose of Field Study

The analysis carried out in chapter three based on the secondary data provides an idea about the pattern of diffusion of AI technology and dynamics of the milk production and bovine population in Assam. It is clear from the analysis that the diffusion of the crossbreeding technology has taken place very lately even though thrust on the crossbreeding programme was laid much earlier. It is seen that the crossbred cattle population in the state constitutes only 3.84 per cent (According to 19th Livestock Census, 2012) of the total cattle population. This implies that there is not enough penetration of the AI technology and exotic bull calf induction programme to the interior most areas where AI technology diffusion is practically cumbersome. If the comparison is made with some of the southern and Northern states of India, it is found that the crossbreeding programme gained momentum much before and resultantly these states are having higher proportion of crossbred cattle in total cattle population (see Table 3.16 in Chapter Three). Again, within the state there are variations with respect to coverage of breedable cattle population using AI technology. It is seen that districts such as Barpeta, Kamrup, Nalbari and Bongaigaon have relatively better coverage of breedable cattle through AI compared to the remaining districts. Thus, it becomes important to understand the drivers of AI technology adoption and economic wellbeing through adopting the technology. This calls for an empirical analysis of the factors that have significantly led to adoption and extent of adoption of crossbreeding technology at the farm household level. This may help to set policy prescription on what factors are important to emphasize in order to increase the adoption rate of crossbreeding technology (i.e., AI). Again farmers will adopt a new technology (crossbred cattle) only if the economic gain from the technology is more compared to traditional technology (indigenous breed). Hence, the impact in terms of income, employment and consumption on the farm households rearing crossbred cattle has to be compared vis-à-vis a farmer rearing indigenous breed. These information however rely completely on primary data collected through a field study owing to paucity/unavailability of adequate secondary data on various farm, farmer, physical environment at which the farmer operates and perception characteristics of the farmer that may facilitate adoption of AI

technology. Data pertaining to various impact indicators such as farmers' income, consumption and employment after rearing crossbred cattle is also dependent on household level data collected through field study. Keeping in mind these requirements, a field study was carried out during December, 2015 to March, 2016 in few selected districts of the state.

Thus, the broad aim of the field study is to understand impact indicators ex-post adopting the technology and examine the factors that influence adoption and extent of adoption (for farmers who have continued adoption) of AI technology (to increase the proportion of crossbred cattle). The field study also attempts to identify the constraints farmers perceive to be inhibiting the adoption of AI technology.

4.2. Sampling and Sample Selection

Primary data are collected from dairy farmers spread over three districts of Assam namely Barpeta, Sonitpur and Karbi Anglong (see Figure 4.1 for the location of the districts). The study has used a multi-stage sampling technique. In the first stage, sample districts are selected following stratified sampling method to capture the diversities in impact and determinants of crossbreeding technology adoption due to various aspects of location specific (spatial) diversities. Using the secondary data available at Assam Livestock Development Agency (ALDA) for the TE (triennium ending) 2013-14, all the 27 districts of the state are first distributed into three strata based on AI coverage of breedable cattle population. The first stratum includes the districts with higher than the national average of AI coverage of breedable cattle population. In the second stratum districts which are below the national average but above the state average are included, and the last stratum includes the districts which are lower than the state average figure. Accordingly, Barpeta, Sonitpur and Karbi Anglong districts are randomly selected from first, second and the third stratum respectively. Barpeta district has the highest AI coverage of breedable cattle population of 25 per cent during TE 2013-14, while Sonitpur has 5.97 per cent coverage. Karbi Anglong with 2.03 per cent is one among the lowest (ranked 4th from below) AI coverage of breedable population districts. In the second stage, two community development blocks (CDBs) are selected purposively from each district considering that one block has higher concentration of crossbred cattle with high AI coverage and the other with relatively lesser concentration and low AI coverage. The selection of the blocks is done in consultation with the senior officials of Assam Livestock Development Agency (ALDA),

District Veterinary officer (DVO) and the Veterinary Doctor who is in-charge of the Block Veterinary Dispensary. Before selection of community development blocks, the purpose of field study was properly explained to these personnels. In the third stage three villages are selected from each development block. This selection is based on the understanding that a mix of both adopters of crossbreeding technology and non-adopters are sufficiently present in each village. It is also taken note while selecting the villages that the spatial distribution of the sampled villages within the block is such that they are by no means contiguous to each other. In the last stage, dairy farm households are selected in two categories: adopter and non-adopter of crossbreeding technology. For operational purpose, the adopter of crossbreeding technology has been defined as the farm households who have at least one calf born through AI during a period of five years preceding the survey and also have at least one in-milk crossbred cattle in his/her farm during the survey. Since, there is lack of concrete information about the list of farmers (both adopter and non-adopter of crossbreeding technology) available with the AI centre and/or veterinary dispensary, a list was prepared through discussion with a group of key informants including the village headman, VS (Veterinary Surgeon) and the VFA (Veterinary Field Assistant) engaged in the AI service of the village. Thus, 20 to 30 per cent of sample farmers are selected from both the adopter and non-adopter groups from each village in all the three districts. A total of 245 respondents (135 adopters and 108 non-adopters) thus selected are interviewed for generating primary data to fulfill the objectives of the study. The primary data were collected through a standard and systematically designed semi-structured interview schedule administered at the farm yard covering different aspects of adoption and impact of cattle crossbreeding. The interview schedule was prepared in consultation with the supervisor of the study and finalized after a few rounds of pilot surveys in each sample district. One Focus Group Discussion (FGD) with few selected respondents is also conducted in each Community Development Block to elicit qualitative information and to have a broad understanding on issues related to dairying in the block. The interview schedule used to collect primary data is appended at the end of this thesis

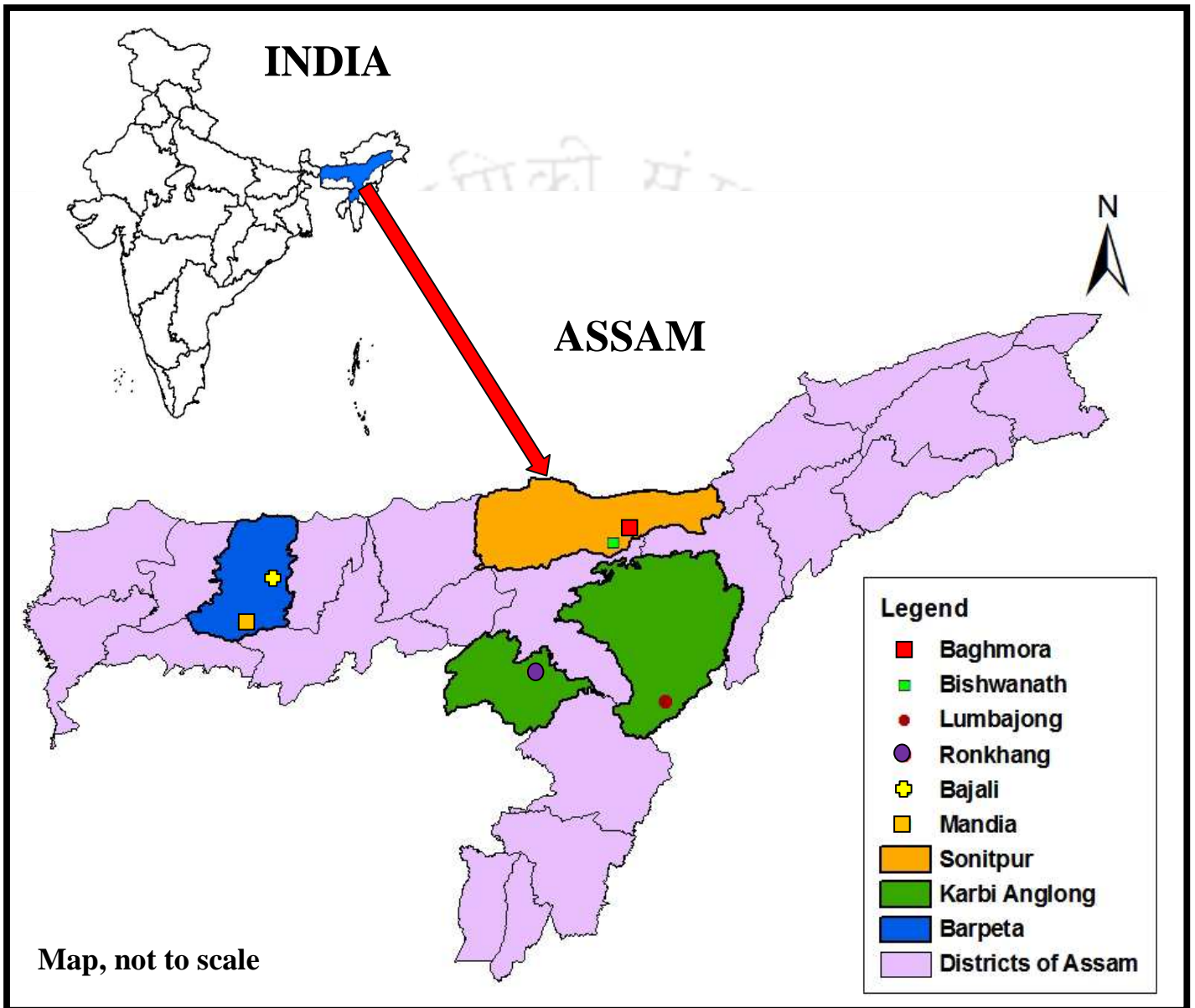


Figure 4.1: Map showing the sample districts and their surveyed community development blocks

The various aspects on which data are collected are household specific, farm input-output specific, cattle breeding and lactation specific, marketing specific and household head's perception specific information. Due emphasis is given on the following aspects: (1) socio-economic issues of the household including gender, age, education, ethnicity and occupation of the household head, family size, land and livestock holding and household's amenities and asset position; (2) Access to institutional assets such as access to credit and household saving strategy, access to extension and infrastructural services; (3) Information regarding breeding characteristics (such as use of AI and natural service (NS), conception rate, access to exotic and local breeding bull etc.), reproduction and lactation characteristics of owned animals (such as age of 1st calving, calving interval, lactation length and number of lactation etc.); (4) Information relating to feeding characteristics of indigenous and crossbred cattle; (5) Milk production and utilization; (6) Information on various cost components, labour requirements and household income according to its sources and (7) information on farmer's perception on constraints to dairy farming.

Presentation and analysis of the data collected through field survey have been laid out in the thesis.

4.3. Broad Profile of the Sample Districts

As discussed above, three districts namely Barpeta, Sonitpur and Karbi Anglong each respectively fall under Lower Brahmaputra valley, North Bank Plain, and Hills zone are selected for the primary survey of the milk producers. The present section gives a brief profile of the three sample districts focusing basically the state of the economy, demographic and geographic profile and veterinary infrastructure. The locations of the districts and the surveyed community development blocks within the districts are shown in Figure 4.1.

4.3.1. Barpeta District

Barpeta district is situated in the latitude of 26.3216° towards North and longitude of 90.9821° towards East. The district is surrounded by Nalbari district in the East and Bongaigaon district in the West. Towards the North of Barpeta district lies the Bhutan hills and towards its South lies Kamrup and Goalpara district. The district head quarter is located

in Barpeta town which is 140 km away from state capital. The district geographically spans 2282 km². The district has two sub-divisions (Barpeta and Bajali), 9 Revenue Circles, 11 Community Development Blocks, 129 Gram Panchayats and 835 villages. The district has two major tribes namely Bodo and Rabha, and Assamese, Bengali, Hindi, and Bodo are the commonly used languages in the district.

According to population census, 2011, Barpeta district has a population of 16,93,622 of which male and female population constitute 8,67,004 and 8,26,618 respectively. During 2001-2011, the district records a population growth rate of 21.43 per cent against the growth rate of 19.62 per cent in the previous decade, i.e., during the inter-census period of 1991-2001. The population of Barpeta district shares 5.43 per cent of the total population of the state. The population density of the district has increased significantly from 521 per km² as per population census, 2001 to 742 per km² as per population census of 2011. The sex ratio of Barpeta district as per population census, 2011 is 953 females per 1000 male population. The average literacy rate in the district is 63.81 per cent of which average male and female literacy rate is 69.29 and 58.06 per cent respectively. The corresponding average literacy rate for Assam as a whole is 72.19 per cent of which average male and female literacy rate of Assam is 77.85 and 66.27 per cent respectively. Like other districts of Assam, a large percentage of the population lives in rural areas. According to population census, 2011, 91.30 per cent of the total population lives in rural areas and the rest 8.70 per cent are dwellers in urban centres of the district.

The total workforce of the district consists of 5,61,824 persons in 2011 representing about 36.33 per cent of the total population of the district. The male and female population workforce participation rate in Barpeta district accounts for about 56.24 and 15.44 per cent respectively. Cultivators and agricultural labourers together account for 54.15 per cent of the total workforce of the district indicating the district's economy mostly of agrarian in nature as agriculture is the main source of livelihood for a vast segment of the population.

Regarding the status of livestock development in the district as per livestock census 2012, Barpeta district has a livestock population of 7,16,944 with percentage share of 3.76 per cent of the total livestock population of the state. The total livestock covers cattle, buffalo, sheep, goat, pig, horses and ponies, mules, Donkeys, Camels, Mithuns and Yak. The percentage

share of various species of livestock in the district indicates that Barpeta district has 3.72 per cent of total cattle population of the state, 6.21 per cent of Buffalo, 18.85 per cent of sheep, 3.16 per cent of goat, and 4.59 per cent of Horses and Ponies. In the total poultry population of the state, the district shares 4.09 per cent which includes total birds in the poultry farms and hatcheries. As on 2012, the veterinary infrastructures in Barpeta district to facilitate veterinary services for its livestock population include 1 veterinary hospital, 13 veterinary dispensaries, 32 sub-centres/stockman centres, 7 block veterinary dispensaries, 4 key village centres and 1 regional artificial insemination centre. As the district is enriched with livestock resources and the economy is largely of agrarian in nature, there is ample scope to increase livestock output through proper programmes and policy.

4.3.2. Sonitpur District

Sonitpur district is situated in the latitude of 26.6739^0 towards North and in the longitude of 92.8577^0 towards East. It is situated in the north bank of river Barhmaputra in the state of Assam. Towards the East of the district lies Lakhimpur district and on the West lies Darrang district. The district is bordered in the North with Arunachal Pradesh. The district headquarter is in Tezpur which is 198 km away from the state capital. District Sonitpur has 3 subdivisions namely, Tezpur (Sadar), Biswanath Chariali and Gohpur and 14 community development blocks that are Gabharu, Bihaguri, Dhekiajuli, Rangapara, Chariduar, Borchala, Naduar, Sootea, Sakomatha, Biswanath, Baghmara, Bihali, Chariduar and Pub-Chaiduar. Apart from this, there are 1876 villages, 158 Gaon Panchayats, 1 Zilla parishad and 7 Revenue Circles. The district with a geographical area of 5204 km^2 is considered as one of the largest districts in the state of Assam. The district is a home for three major tribes namely, Mishing, Bodos and Adivasis (Tea-tribes). The commonly used languages in the Sonitpur district are Assamese, Bengali, Bodo, Nepali and Hindi. According to population census of 2011, actual population of the district is 19,24,110 (6.17 per cent of the total state population) of which male and female population respectively constitute 9,83,904 and 9,40,206. During the inter-census period of 2001 and 2011, 15.55 per cent growth rate in the population was recorded which is relatively lesser than the growth rate of 18.11 per cent recorded in the previous decade. The population density in the district is $370/\text{km}^2$. Like other districts of the state, 90.96 per cent of the total population live in rural areas and urban

population constitute only 9.04 per cent. As per population census 2011, the average literacy rate in Sonitpur district is 67.34 per cent of which average male and female literacy rates respectively are 73.65 and 60.73 per cent.

The total workforce of Sonitpur district consists of 7,70,606 persons in 2011 representing 40.05 per cent of the total population of the district. The proportion of male and female workforce participation rate into the total workforce participation are respectively 69.71 and 30.29 per cent. Again of the total workforce participation in the district, 91.94 per cent workforce is in rural areas and the remaining 8.06 per cent is the urban workforce. Cultivators and agricultural labourers together account for about 47.23 per cent of the total workforce of the district revealing that agriculture is the predominant source of livelihood in the district.

According to the 19th Livestock Census, 2012 the total livestock in Sonitpur district is 16,50,571 that constitute 8.64 per cent of total livestock population of the state. The percentage share of poultry population of Sonitpur district is 6.03 per cent of the total poultry population in the state. Sonitpur is the home for a large number of livestock species. As per the Livestock Census of India, 2012, the district houses the highest proportion of cattle population (9.14 per cent) among the districts in the state. It also accommodates third highest share of total buffalo population (8.30 per cent) in the state and second highest share of goat (8.13 per cent) and pig (9.57 per cent) population in Assam. The percentage share of other livestock species such as Sheep and Horses and Ponies are 2.60 and 1.86 per cent respectively. Of the total bovine population in the district, 99.08 per cent is found in rural areas and the remaining 0.92 per cent is found in the urban parts of the district. As far availability of veterinary facilities are concerned, as on 2012 the district has 2 veterinary hospitals and 17 dispensaries against the total number of 22 hospitals and 346 veterinary dispensaries in the state. Other veterinary facilities that Sonitpur district has are 65 sub-centres/stockman centre, 7 block veterinary dispensaries, 4 key village centres and 3 Regional Artificial Insemination Centres (RAIC).

4.3.3. Karbi Anglong District

Karbi Anglong district is situated between 25⁰33' and 26⁰35' North latitude and 92⁰10' to 93⁰50' East longitude. Towards the East of Karbi Anglong district lies Golaghat district and in the West Morigaon district and Meghalaya. To the North Nagaon and Golaghat district is located while towards the South of Karbi Anglong lies Dima Hasao district and Nagaland. The administrative headquarter of Karbi Anglong district is Diphu which has a distance of 278 km from the state capital. The district has three subdivisions namely Diphu, Bokajan and Hamran. There are four Revenue Circles that are named as Diphu, Phuloni, Silonijan and Donka. Karbi Anglong district has 11 community development blocks and 2921 villages. The main towns of the district are Diphu, Dokmoka, Howraghat, Bokajan, Hamren and Dongkamokam. According to Population Census 2011, the total geographical area of the district is 10,434 km². As per the Census of 2011, the actual population of the district is 9,56,313 constituting 51.26 per cent male and 48.74 per cent female population. During the inter-census period of 2001 and 2011, the growth rate of the population recorded at 17.58 per cent against the growth rate of 22.72 per cent in the previous decade. Karbi Anglong district has a population density of 92 per km² and considered as one of the low population density districts in the state. It has 3.06 per cent of the total population in Assam. In Karbi Anglong district 88.19 per cent of the total district population live in rural areas and the rest 11.81 per cent live in the urban parts of the district. As per population census, 2011 the proportion of children population (0-6 age) accounts for 15.80 per cent in the district. Again, the number of female population per 1000 male population is 951 as per population census, 2011. The average literacy rate in the district is 69.25 per cent in 2011 which increased from the literacy rate of 57.70 per cent in 2001. The male literacy rate in the district is 76.14 per cent against the female literacy rate of 62.00 per cent as per estimates of Population Census, 2011.

The total workforce in the Karbi Anglong district is 3,83,441, as per the 2011 Population Census of India. Of the total workforce, male workers constitute 64.21 per cent while female workers account for 35.79 per cent. Again, out of the total workers in the district 67.93 per cent is the main workers while 32.07 per cent are the marginal workers. Cultivators and agricultural labourers together constitute 74.06 per cent of the total workforce in the district indicating that agriculture remains as the mainstay to earn livelihood for a vast section of population in the district.

The total livestock population in Karbi Anglong district is 8,22,729 with share of 4.31 per cent of the total livestock population of the state. The total poultry population of Karbi Anglong district accounts for 5.01 per cent of total poultry population of Assam. The percentage share of total cattle and buffalo population in Karbi Anglong district is 3.52 and 3.43 per cent respectively. Among the districts in Assam, Karbi Anglong has the highest share of pig population with 9.92 per cent in the total pig population of the state. The highest share of pig population in the district is attributed to the dominance of tribal population of the district who are specialized in pig farming. The other livestock species such as goat, and horses and ponies account for 4.56 and 1.45 per cent of the total goat, and horses and ponies population of the state respectively. Like Sonitpur district 99.13 per cent of the total bovine population is reared in the rural areas of the district. Diffusion of veterinary facilities in a district likely to affect livestock development and also may facilitate adoption of improved livestock rearing practices. The status of veterinary facilities indicate that there are 10 veterinary dispensaries, 42 sub-centres/stockman centres, 10 block veterinary dispensaries and 1 Regional Artificial Insemination Centre (RAIC). Unlike Barpeta and Sonitpur district, the district is not found with any veterinary hospital and key village centre.

4.4. Composition of the Sample

Table 4.1 to Table 4.4 shows the village-wise distribution of sample households across the sample districts of the study. Of the total 245 households surveyed in three districts of Assam, 37.55 per cent households are surveyed in Barpeta district while the proportion of sample households surveyed in Sonitpur and Karbi Anglong districts is 33.47 per cent and 28.98 per cent respectively. Due to relatively high AI adoption intensity in Barpeta district the survey covered relatively higher proportion of adopter households compared to other two districts. Of the total 137 adopters surveyed 39.42 per cent are from Barpeta district whereas 31.39 per cent from Sonitpur and 29.2 per cent from Karbi Anglong district. Out of the 108 non-adopters as a control group of the study surveyed in the three districts, the proportion of households is 35.19, 36.11 and 28.7 per cent in Barpeta, Sonitpur and Karbi Anglong district respectively (see Table 4.1).

Table 4.1: Sample Districts with Number of Sample Farms

Name of District	Adopter	Non-adopter	Total
Barpeta	54 (39.42)	38 (35.19)	92 (37.55)
Sonitpur	43 (31.39)	39 (36.11)	82 (33.47)
Karbi Anglong	40 (29.20)	31 (28.70)	71 (28.98)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16; **Note:** Figure in parentheses indicates percentage to column total

The two community development bocks (CDB) surveyed in Barpeta district are Bajali and Mandia where 48 per cent of the total sample households are from Bajali CDB and 52 per cent from Mandia CDB. The villages covered in Bajali CDB are Belana, Dumuria and Ratanpur. Except Belana and Dumuria where the sample households with crossbreeding technology adoption and non- adoption are almost evenly distributed the remaining village

Table 4.2: Survey Locations with Number of Sample Farms in Barpeta District

Name of the village	Adopter	Non-adopter	Total
A. Bajali CDB			
Belana	7 (12.96)	6 (15.79)	13 (14.13)
Dumuria	8 (14.81)	7 (18.42)	15 (16.30)
Ratanpur	15 (27.78)	1 (2.63)	16 (17.39)
Total	30 (55.56)	14 (36.84)	44 (47.83)
B. Mandia CDB			
Moripam	8 (14.81)	8 (21.05)	16 (17.39)
Mandia	8 (14.81)	8 (21.05)	16 (17.39)
Agmandia	8 (14.81)	8 (21.05)	16 (17.39)
Total	24 (44.44)	24 (63.16)	48 (52.17)
Total (A+B)	54 (100)	38 (100)	92 (100)

Source: Field survey, 2015-16

Note: Figure in parentheses indicates percentage to column total

Ratanpur has a much higher concentration of AI adopters relative to bull user. In Mandia CDB, Moripam, Mandia and Agmandia are the three surveyed villages. It is found by making initial general overview of the villages and through discussion with the Village

Headman, Veterinary Doctor and Veterinary Field Assistant (VFA) that the distribution of sample villages in Mandia CDB is almost evenly distributed between adopter and non-adopter groups. Hence, an equal proportion of sample households are surveyed in all the three villages in this block (see Table 4.2).

Of the three surveyed districts, Sonitpur is incorporated as one of the sample districts in the study that falls as medium category district in terms of AI coverage of breedable cattle population (5.97 per cent). The two surveyed CDBs are Biswanath and Baghmora in which almost 51 and 49 per cent of the total sample households surveyed in the district are covered respectively. The villages surveyed in Biswanath CDB are Panibharal, Kadamani and Galia, while in Baghmora CDB Gelapukhuri, North Gingia and East Gingia are surveyed (see Table 4.3 for village wise percentage distribution of sample farmers of Sonitpur district).

Table 4.3: Survey Locations with Number of Sample Farms in Sonitpur District

Name of the village	Adopter	Non-adopter	Total
A. Biswanath CDB			
Panibharal	8 (18.60)	6 (15.38)	14 (17.07)
Kadamani	7 (16.28)	7 (17.95)	14 (17.07)
Golia	7 (16.28)	7 (17.95)	14 (17.07)
Total	22 (51.16)	20 (51.28)	42 (51.22)
B. Baghmora CDB			
Gelapukhuri	8 (18.60)	7 (17.95)	15 (18.29)
North Gingia	7 (16.28)	6 (15.38)	13 (15.85)
East Gingia	6 (13.95)	6 (15.38)	12 (14.63)
Total	21 (48.84)	19 (48.72)	40 (48.78)
Total (A+B)	43 (100)	39 (100)	82 (100)

Source: Field survey, 2015-16

Note: Figure in parentheses indicates percentage to column total

Table 4.4 presents the village-wise distribution of sample farmers across crossbreeding technology adoption category in Karbi Anglong district. Since the AI activity was carried out lately in this district intensity of AI adoption is found to be relatively less and thus the

sample households covered is also less compared to sample households covered in Barpeta and Sonitpur district. Lumbajong and Rongkhang CDBs are surveyed constituting 57.5 and 42.5 per cent of adopters respectively and 45 and 55 per cent of non-adopters respectively. Thus, a total of 52 per cent households are surveyed in Lumbajong CDB and 48 per cent in Rongkhang CDB. The villages included are Saraswati Mandir, Taralangshu and 9th Mile (Nepali Basti) in Lumbajong CDB and Dongka, Tisugao and Kolonga in Rongkhang CDB (see Table 4.4).

Table 4.4: Survey Locations with Number of Sample Farms in Karbi Anglong District

Name of the village	Adopter	Non-adopter	Total
A. Lumbajong CDB			
SaraswatiMandir	8 (20.00)	6 (19.35)	14 (19.72)
Taralangshu	7 (17.50)	6 (19.35)	13 (18.31)
9 th Mile (Nepali Basti)	8 (20.00)	2 (6.45)	10 (14.08)
Total	23 (57.50)	14 (45.16)	37 (52.11)
B. Rongkhang CDB			
Dongka	5 (12.50)	5 (16.13)	10 (14.08)
Tisugao	6 (15.00)	6 (19.35)	12 (16.90)
Kolonga	6 (15.00)	6 (19.35)	12 (16.90)
Total	17 (42.50)	17 (54.84)	34 (47.89)
Total (A+B)	40 (100)	31 (100)	71 (100)

Source: Field survey, 2015-16

Note: Figure in parentheses indicates percentage to column total

4.5. Sample Profile and Socio-Economic Characteristics

In this section an attempt is made to analyze the socio-economic characteristics of the sample households.

4.5.1. Ethnic and Religious Profile of the Sample Farmers Engaged in Dairying

The major ethnic groups engaged in the dairy activity in the state of Assam are represented by the distribution of sample farmers according to the various communities that constituted

the surveyed households of the three selected districts in the study. The classification of the ethnic groups is made based on the linguistic differences and to capture the ethnicity-wise heterogeneity in the practice of rearing high yielding crossbred cattle and adoption of AI technology.¹ The present study also attempts to investigate if any ethnicity-based differences may be found in assessing the determinants of crossbreeding and impact of rearing high yielding crossbred cattle. Table 4.5 and 4.6 presents the distribution of major ethnic groups of the surveyed 245 households.

Table 4.5: Major Ethnic Groups Engaged in Dairying in the Sample Districts

Ethnic groups	Barpeta	Sonitpur	Karbi Anglong
Assamese	40 (43.48)	8 (9.76)	1 (1.41)
Bengali [#]	51 (55.43)	11 (13.41)	15 (21.13)
Nepali	0 (00.00)	51 (62.19)	32 (45.07)
Bihari	1 (1.09)	6 (7.32)	17 (23.94)
Others	0 (00.00)	6 (7.32)	6 (8.45)
Total	92 (100)	82 (100)	71 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to total; [#] The Bengali community also includes the Bengali speaking Muslims found in the sample; * Others include Karbi, Dimasa, Adivasi and Lalung

It is seen that after the ethnicity-wise disaggregation of the sample households into five major groups, Nepali community shares the highest of the dairy activity (34 per cent) in the state followed by the Bengali community (includes Bengali speaking Muslim community) with 31 per cent. The share of the Assamese community in the number of sample households is 20 per cent followed by the Bihari community (9.79 per cent). Other community that is mostly constituted by the various tribal communities of Karbi Anglong district that carries out dairy activity in the state shares 4.90 per cent of the surveyed households. It is evident from Table 4.5 that Bengali community seems to be more specialized in rearing indigenous breed whereas Assamese and Nepali community are found to be interested in rearing of high yielding crossbred cattle through adoption of AI technology. The district-wise decomposition of the ethnic groups entails that in Barpeta district Bengali and Assamese community is dominant with their respective share of 55.43 per cent and 43.48 per cent in the total surveyed households in the district. There is absence

of Nepali and Bihari community associated with dairying among the surveyed households in Barpeta district. However, in Sonitpur and Karbi Anglong district there is a much higher concentration of dairy activity in the hands of Nepali community. The share of Nepali respondents among the total respondents of Sonitpur and Karbi Anglong district is 62.2 and 45.07 per cent respectively. The Assamese community has a much lower share of 10 per cent in Sonitpur and 1.41 per cent in karbi Anglong district.

Table 4.6: Major Ethnic Groups Engaged in Dairying among the Sample Households

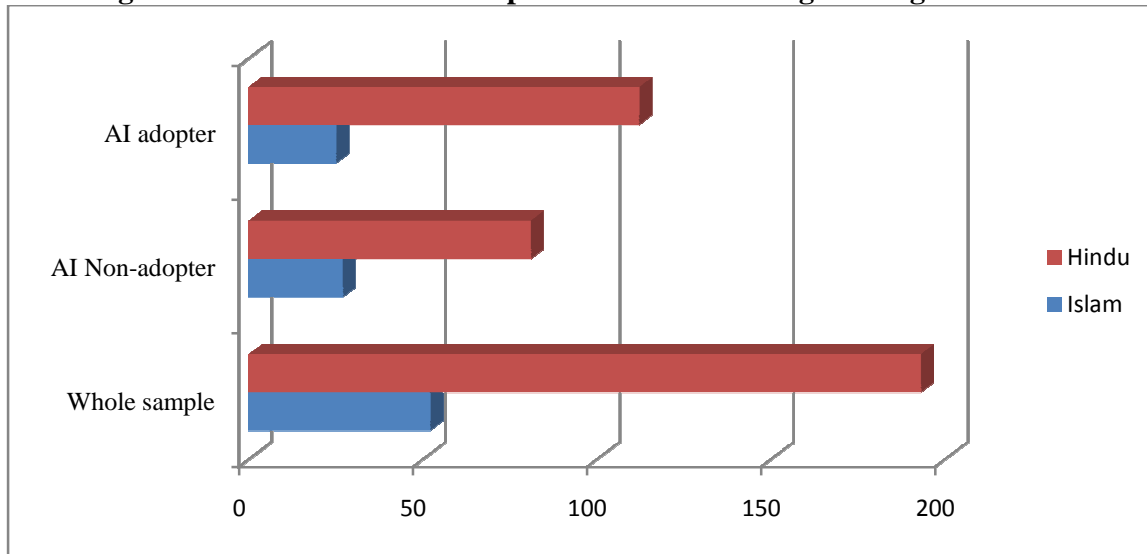
Ethnic groups	No. of sample farms households		
	Adopter	Non-adopter	Total
Assamese	33 (24.09)	16 (14.81)	49 (20.00)
Bengali [#]	36 (26.28)	41 (37.96)	77 (31.43)
Nepali	52 (37.96)	31 (28.70)	83 (33.88)
Bihari	10 (7.30)	14 (12.96)	24 (9.79)
Others*	6 (4.38)	6 (5.56)	12 (4.90)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to total; [#]The Bengali community also includes the Bengali speaking Muslims found in the sample. * Others include Karbi, Dimasa, Adivasi, and Lalung.

Looking at the composition of sample respondents broadly at religious line, it is divided between two major religious groups, Hindu and Islam. Figure 4.2 exhibits the distribution across adoption categories. It is found that of the total sample respondents in the three districts 79 per cent belongs to Hindu religion while 21 per cent are Islam. The distribution of the sample respondents on religious groups across crossbreeding technology adoption status indicates that of the 137 adopters, almost 82 per cent are from Hindu religion; whereas 18 per cent from Islam. Again, of the 108 sample respondents with non adoption of cattle crossbreeding, 75 per cent are Hindu and 25 per cent are Muslim (see Figure 4.2).

Figure 4.2: Distribution of Sample Farmers According to Religious Profile



4.5.2. Family Size

The average family size of the overall sample households is 5.91 with a minimum family size of 1 member and a maximum of 18 members. The average family size for the adopter category is 5.72 and 6.14 for non-adopter's category. Distribution of the family size according to various age group is represented in Table 4.7 where it is seen that average number of adult members for the whole sample is 4.33 (4.26 for adopters and 4.42 for non-adopters). Similarly, the average number of young members and children is 0.90 and 0.73 respectively for the whole sample surveyed in the three districts of Assam (see Table 4.7).

Table 4.7: Size of the Sample Households According to Different Age Groups across Crossbreeding Technology Adoption Status

Family size	Adopter	Non-adopter	Total
Average Family Size	5.72	6.14	5.91
Maximum size	17	18	18
Minimum size	1	1	1
Average No. of Adult Members (>14 years)	4.26	4.42	4.33
Average No. of Young Members (6-14 years)	0.77	1.06	0.90
Average No. of Children (<6 years)	0.71	0.77	0.73

Source: Field survey, 2015-16

4.5.3. Educational Profile of the Sample Farmers

Information on education profile of the sample farmers is very important in the present study in terms of its relevance in the adoption of improved dairy technology and acceptance of improved farm practices for realizing higher farm productivity. Education profile of the head of the sample household is shown in Table 4.8. It is to note that the education profile of the household head was collected as years of schooling during the primary survey. It is found from the table that 26.12 per cent of the total sample household's heads are illiterate. More than half of the total literate farmers have education level of primary to below matriculate. Farmers being matriculate but below higher secondary constitute 23.2 per cent of the total literate farmers. Similarly, farmers having education level in the range of HS passed but under graduate forms 13.26 per cent of the total literate sample farmers. Only a 5 per cent of the total sample farmers have graduation or post graduate degree. It is witnessed from the table that majority of the sample farmers have attained lower level of education in terms of last class attended by them.

Table 4.8: Distribution of Sample Farmers According to the Level of Education of the Household Head

Education level	No. of sample households
Illiterate	64 (26.12)
Primary (up to class V)	39 (15.92)
Primary passed but not matriculate	64 (26.12)
Matriculate but below Higher Secondary	42 (17.14)
Higher Secondary passed but under Graduate	24 (9.79)
Graduation and above	12 (4.90)
Total	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to total

4.5.4. Age profile of the sample farmers

Table 4.9 presents the distribution of sample farm households according to the age of the household head. Perusal of Table 4.9 indicates that the majority of the sample farmers are in the age group of 40 to 70 years of age. The minimum age of the sample farm household head is found to be 22 years while the maximum is 77 years. According to the different age cohort of the sample farmers as represented by Table 4.9 indicates that only a 2.04 per cent

of the sample farmers are in the age group of less than 30 years of age. Highest number of farmers are found in the age group of 40 to 50 years (28.57 per cent) followed by the number of farmers in the age group 50 to 60 years (24.49 per cent). Highly aged farmers with more than 70 years have a percentage share of 6.53 in the total sample farmers. Distribution of sample farmers according to crossbreeding technology adoption category indicates that farmers in the age group of 30 to 40 years constitute 20.44 per cent among the adopter group whereas in the non-adopter group the proportion is 14.81 per cent. The distribution of farmers is the higher towards non-adopters in the age group 40 to 60 years against the AI adopter (Table 4.9).

Table 4.9: Distribution of Sample Farm Households According to the Age of the Household Head across AI Adoption Groups

Age group of household head	Adopter	Non-adopter	Total
< 30 years	2 (1.46)	3 (2.78)	5 (2.04)
30 < 40 years	28 (20.44)	16 (14.81)	44 (17.96)
40 < 50 years	36 (26.28)	34 (31.48)	70 (28.57)
50 < 60 years	32 (23.36)	28 (25.93)	60 (24.49)
60 < 70 years	29 (21.17)	21 (19.44)	50 (20.41)
> 70 years	10 (7.30)	6 (5.56)	16 (6.53)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to column total

4.5.5. Occupational Profile of the Sample Farmers

Table 4.10 and Table 4.11 exhibit the occupational profile of the sample farmers. It is found from Table 4.10 that around 33 per cent of the total sample farmers have reported dairying as their primary activity to earn livelihoods. There are also a large number of farmers (34.69 per cent) who report cultivation as their primary source of livelihood. Proportion of farmers engaged in off-farm activities such as wage employment, govt. and private service and business as their primary source of earning are 8.57, 15.74, 2.45 and 13.88 per cent respectively. A large number of farmers adopting crossbreeding technology report dairying as their primary occupation (47.45 per cent), while the proportion of non adopting farmers who consider dairying as primary activity is 13.89 per cent. Again, 30.66 per cent of the

crossbreeding technology adopting farmers and 39.81 per cent of the non-adopting farmers consider cultivation as primary activity (Table 4.10).

Table 4.10: Distribution of Sample Households According to the Primary Occupation of the Household Head across Adoption Groups

Occupation type	No. of sample farm households		
	Adopter	Non-adopter	Total
Dairying	65 (47.45)	15 (13.89)	80 (32.65)
Cultivation	42 (30.66)	43 (39.81)	85 (34.69)
Wage Earner	4 (2.92)	16 (14.81)	21 (8.57)
Govt. Service	8 (5.84)	9 (8.33)	17 (15.74)
Private Service	1 (0.73)	5 (4.63)	6 (2.45)
Business	16 (11.68)	18 (16.67)	34 (13.88)
Other	0 (00)	2 (1.85)	2 (0.82)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to column total

It is found from Table 4.11 that out of the total 245 sample farmers the number of farmers reporting dairy as secondary occupation is 189 of which 103 farmers are adopters and 86

Table 4.11: Distribution of Sample Household According to the Secondary Occupation of the Household Head across Adoption Groups

Occupation type	No. of sample farm households		
	Adopter	Non-adopter	Total
Dairying	103 (75.18)	86 (79.63)	189 (77.14)
Cultivation	28 (20.44)	13 (12.04)	41 (16.73)
Wage Earner	2 (1.46)	4 (3.70)	6 (2.45)
Govt. Service	0 (00)	1 (0.93)	1 (0.41)
Private Service	0 (00)	1 (0.93)	1 (0.41)
Business	3 (2.19)	3 (2.78)	6 (2.45)
Other	1 (0.73)	0 (00)	1 (0.41)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to column total

farmers are non-adopter of crossbreeding technology. This implicates that a large number of farmers are primarily engaged in other source of income generating activities apart from being engaged in dairy farming. Next to dairying, 20.44 per cent and 12.04 per cent of the adopters and non-adopters respectively are engaged in cultivation as secondary source of employment. A very small proportion of sample farmers of both adopter and non-adopter of crossbreeding technology are found to be considering the various off farm sources of income as secondary occupation (see Table 4.11).

Table 4.12 explains the overall importance of dairying among the sample farmers across the crossbreeding technology adoption groups. The first row of the first column indicates the extent of sample farmers having pure agricultural background (either dairying or cultivation) and their respective distribution in terms of crossbreeding technology adoption and non-adoption. It is found that 61.63 per cent of the total sample farmers in the three surveyed districts have dairying or cultivation as primary or secondary occupation. The remaining 38.37 per cent have off-farm sources of income as either primary or secondary occupation. The second row of the first column indicates the number of sample farmers having complete reliance on dairying as their livelihood source (dairy as both primary and secondary occupation). It is seen that out of 245 respondents only 15.51 per cent earn their income solely from dairy farming. Again, 23.36 per cent sample respondents from adopter group and 5.56 per cent from non-adopter group have complete dependence on dairying. It can be

Table 4.12: Distribution of Sample Households According to the Priority of Dairying as Primary/Secondary Occupation

Priority of Dairying	Response	Adopter	Non-adopter	Total
Dairying and cultivation as either primary or secondary occupation	Yes	101 (73.72)	50 (46.30)	151 (61.63)
	No	36 (26.28)	58 (53.70)	94 (38.37)
Dairying as both primary and secondary occupation	Yes	32 (23.36)	6 (5.56)	38 (15.51)
	No	105 (76.64)	102 (94.44)	207 (84.49)
Dairying being neither primary nor secondary occupation	Yes	1 (0.73)	13 (12.04)	14 (5.71)
	No	136 (99.27)	95 (87.96)	231 (94.29)
Total		137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to total

assumed that these farmers may have commercial dairy farm from which family income is generated. The third row of the first column in Table 14 distributes the sample respondents according to number of farmers with dairy farm but having very insignificant role of it on their livelihood (have occupation other than dairy farm as primary or secondary income source). It is found that 5.71 per cent (14 number of sample farmers) of the total respondents have dairy farm but it is neither a primary nor a secondary source of income for them. Across crossbreeding technology adoption groups, only 0.73 per cent of adopters and 12.04 per cent non-adopters have dairy farming which is neither a primary nor a secondary occupation for them (Table 4.12).

4.5.6. Housing Condition and Access to Assets and Amenities

Information on housing condition of the sample farmers collected in the field survey reveal that 35.51 per cent of the total sample farmers have *kutcha* houses, 33.88 per cent have *semi-pucca* houses and the rest 30.61 per cent have *pucca* houses. According to crossbreeding technology adoption category, 37.96, 28.47 and 33.58 per cent adopters have *kutcha*, *semi-pucca* and *pucca* house respectively. Similarly 32.41, 40.74 and 26.85 per cent of non-adopters have *kutcha*, *semi-pucca* and *pucca* house respectively (Table 4.13). Table 4.13 also indicates about the percentage of farmers owning other assets and amenities such as cooking gas, sanitized latrine facility, electricity connection, mobile phones, television, two wheelers, bullock cart, four wheelers, tractor, power tiller, cello tube-well etc. Information on access to other subsidized govt. provisions such as ration card and/or BPL card owned by the sample farmers were also collected during the field survey which are reported in Table 4.13. It is found that 67.76 per cent of the total sample farmers have cooking gas connection and 43.27 per cent have sanitized latrine facility at their home. Majority of the surveyed households have electricity connection (92.24 per cent) which may have become possible due to the recent mass rural electrification scheme (*Rajiv Gandhi Grameen Vidyutikaran Yojana, 2015*) to provide free and subsidized electricity connection to poor households. To have better access to information and communication facility majority of sample households have mobile phone connection (almost 94 per cent) and even many of the sample households have television (70.20 per cent) at their home. To have better mobility and reduce transaction cost, own transportation facility may help the farmers and this may also

indirectly help in adopting new agricultural technology. It is envisaged from Table 4.13 that of the total 245 sample households, almost 36 per cent are found to possess a two wheeler, 1.22 per cent a bullock cart and 3.67 per cent to possess a four wheeler.

Table 4.13: Household Access to Amenities and Assets of the Sample Farmers across Adoption Groups

Assets and Amenities	Adopter	Non-adopter	Total
<i>Housing condition</i>			
<i>Pucca</i> House	46 (33.58)	29 (26.85)	75 (30.61)
<i>Semi-pucca</i> House	39 (28.47)	44 (40.74)	83 (33.88)
<i>Kutcha</i> House	52 (37.96)	35 (32.41)	87 (35.51)
<i>Assets and amenities</i>			
Cooking Gas	91 (66.42)	75 (69.44)	166 (67.76)
Latrine (Sanitized)	59 (43.07)	47 (43.52)	106 (43.27)
Electricity Connection	130 (94.89)	96 (88.89)	226 (92.24)
Mobile Phones	131 (95.62)	99 (91.67)	230 (93.88)
Television	97 (70.80)	75 (69.44)	172 (70.20)
Two Wheelers	51 (37.23)	37 (34.26)	88 (35.92)
Bullock Cart	3 (2.19)	0 (00)	3 (1.22)
Four Wheelers	6 (4.38)	3 (2.78)	9 (3.67)
Tractor	2 (1.46)	3 (2.78)	5 (2.04)
Power Tiller	2 (1.46)	2 (1.85)	4 (1.63)
Cello Tube-well	29 (21.17)	23 (21.30)	52 (21.22)
Subsidized Ration Card	101 (73.72)	81 (75.00)	182 (74.29)
BPL Card	17 (12.41)	20 (18.52)	37 (15.10)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to total

Possession of income generating assets such as tractor, power tiller and cello tube-well may have some indirect implication on changing the pattern of dairy farm practices along with

the perceived direct effect on cultivation practices. Possession of these may also signify the wealth position of the sample farmers. However, it is found that only 2.04 per cent of the sample households have tractor, 1.63 per cent have power tiller and 21.22 per cent have cello tube-well. It is also seen that 74.29 per cent farm households have access to subsidized ration card and 15.10 per cent have BPL card (Table 4.13).

4.5.7. Household Access to Institutional Credit and Savings

The household access to institutional services across crossbreeding technology adoption category is reported in Table 4.14. It shows that only 16.33 per cent sample farmers have access to formal credit with average amount of credit accessed is Rs. 98625.00 during a period of 5 years preceding the survey. According to crossbreeding technology adoption category, 15.33 per cent of the adopting farmers have accessed formal credit and 17.59 per cent of non- adopting farmers have access to formal credit facility. The maximum amount of credit received by AI adopters is Rs. 500000 while it is Rs. 200000 by the farmers in the non-adopter category. It is found in Table 4.14 that a sizable number of farmers are found to have access to banking services in terms of possession of bank account (76.33 per cent for the whole sample) during the survey period which may have resulted due to the massive financial inclusion scheme of the Govt. called “Pradhan Mantri Jana Dhan Yojana” initiated on August, 2014.

Table 4.14: Household Access to Institutional Credit and Savings of Sample Farmers across Adoption Groups

Institution	Adopter	Non-adopter	Total
Access to Formal Credit Sources	21 (15.33)	19 (17.59)	40 (16.33)
Maximum Amount Received	500000	200000	500000
Average Amount Received	74309.52	54447.37	98625.00
Financial Inclusion*	104 (75.91)	83 (76.85)	187 (76.33)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to total; *Financial inclusion indicates about farmers having bank account in formal financial institutions.

4.6. Agrarian Structure of the Sample Farmers

In the following section an attempt is made to analyze the composition of the sample farm households and their agrarian structure like size of own agricultural holding, total operational holding and livestock holding across adopter and non-adopter of crossbreeding technology.

Distribution of sample farm households according to the size of their own agricultural land holding and operational holding are shown in Table 4.15 and Table 4.16 respectively. Separate presentation of agricultural land holding and operational holding is based on the understanding that former is considered as clear representation of the asset position of the household while the later is an indicator of relative intensity of agricultural activities of the household. Table 4.15 shows that 41.22 per cent of the total sample households belong to the landless category. Marginal farmers with own agricultural land holding of less than 1 hectare constitute 44.08 per cent followed by small farmers (11.02 per cent). Only 1.22 and 2.45 per cent belong to semi-medium and medium farmers respectively. There are no large farmers found among the surveyed households in the study. Among the adopters 36.36 per cent are landless farmers, while from non- adopters 47.22 per cent are landless. Again, 46.72 and 40.74 per cent for adopter and non-adopters respectively have own agricultural holding of less than 1 hectare. Farmer households with 1 to 2 hectare of own agricultural holding constitute almost 11 per cent for both adopter and non-adopter groups (Table 4.15).

Table 4.15: Distribution of Sample Farm Household According to Own Agricultural Holdings

Size classes of own agricultural holding	Adopter	Non-adopter	Total
Landless	50 (36.36)	51 (47.22)	101 (41.22)
Marginal (below 1.00 hectare)	64 (46.72)	44 (40.74)	108 (44.08)
Small (1 – 2 hectares)	15 (10.95)	12 (11.11)	27 (11.02)
Semi-medium (2 – 4 hectares)	2 (1.46)	1 (0.93)	3 (1.22)
Medium (4 – 10 hectares)	6 (4.38)	0 (00)	6 (2.45)
Large (above 10 hectares)	0 (00)	0 (00)	0 (00)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to column total

The distribution of sample farm household according to their operational holding is presented in Table 4.16. The value of distribution according to size of operational holding in Table 4.16 may differ from the distribution of land holding in Table 4.15 due to consideration of land sharing agreements between farmers (based upon leasing in/out or mortgaged in/out). Table 4.16 shows that 32.65 per cent sample farmers are landless with 27.01 per cent in the adopter category and 39.81 per cent in the non-adopter category. Considering the land holders across size classes, it is seen that maximum concentration of sample farmers is in the size category of less than 1 hectare (almost 45 per cent) with adopter category having 46.72 per cent of the farmers and 42.59 per cent for non-adopters. The small and semi-medium farmers account for 16.33 and 4.49 per cent respectively for the whole sample surveyed in the three districts of Assam.

Table 4.16: Distribution of Sample Farm Household According to their Operational Holdings

Size classes of operational holding	Adopter	Non-adopter	Total
Landless	37 (27.01)	43 (39.81)	80 (32.65)
Marginal (below 1.00 hectare)	64 (46.72)	46 (42.59)	110 (44.90)
Small (1 – 2 hectares)	27 (19.71)	13 (12.04)	40 (16.33)
Semi-medium (2 – 4 hectares)	7 (5.11)	4 (2.92)	11 (4.49)
Medium (4 – 10 hectares)	2 (1.46)	2 (1.85)	4 (1.63)
Large (above 10 hectares)	0 (00)	0 (00)	0 (00)
Total	137 (100)	108 (100)	245 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to column total

4.7. Summing up

The chapter presents detailed discussions on sampling and sample profile, composition of the sample and descriptive statistics on various socio-economic characteristic of the sample farmers collected from selected districts of the state. The broad profile of the sample farmers of both adopter and non-adopter of crossbreeding technology provides a background for more intensive analysis of the issues related crossbreeding of cattle through adoption of AI technology. Thus in the following chapter, intensive discussion based on the primary survey data is presented. Issues with respect to milk productivity of indigenous and crossbred cattle,

economics of milk production, labour use statistics and marketing and marketed surplus of milk among the sample farmers are analyzed using simple analytical techniques such as mean, ratios, percentages, *t*-test and multivariate regression.

Notes:

1. It is observed during the field survey that certain immigrated ethnic groups (e.g. Nepali and Bihari community) have better expertise in rearing crossbred cattle, carry out dairy business in the peri-urban parts of Karbi Anglong and Sonitpur district and have prompt behavior to adopt AI technology.



CHAPTER FIVE

MILK PRODUCTIVITY AND THE UNDERLYING ISSUES OF MILK PRODUCTION

In the previous chapter a broad profile of the sample farmers are presented. The milk productivity and production may be influenced by availability of various types of inputs (both domestically and purchased) including family labour required for bovine milk production. The availability of such inputs may have a bearing on increased profitability, various lactation and reproduction traits of the animals, strengthening of input-output relation, labour use in farm management, and availability of milk marketing options. The aforesaid issues related to raising milk production may also connect with the adoption of improved dairy technology such as high yielding crossbred cattle. Therefore, in this chapter, an attempt is made to know the broader economics associated with milk production, factors influencing farm profitability and farm productivity, various physiological characteristics of the animal related to milk productivity, labour use pattern according to various farming operations, gender and farm types, nature and accessibility of market and determinants of marketed surplus. The analysis has taken into cognizance the empirical findings of several studies carried out in various states of India including Assam.

The chapter is organized under five sections. Section 5.1 makes categorization of the sample farms based on the average size of cattle holding and accordingly distributes the sample households across the sample districts. Section 5.2 discusses the milk productivity, lactation and reproduction characteristics and input-output relation in milk production across the breed of cattle (crossbred and indigenous). Section 5.3 analyses the economics of dairy farming and discusses the determinants of profitability of dairying among the sample farmers. Section 5.4 discusses the employment in dairying among sample farmers, while section 5.5 presents the discussions on issues of marketing and marketed surplus of milk. Section 5.6 finally sums up the whole discussions of the chapters.

5.1. Farm Type and Distribution of Sample Farms

Table 1 presents the break-up of sample respondents according to various herd size categories in the three sample districts of the state and according to crossbreeding technology adoption status. Standard Animal Unit (SAU)¹ is derived from Kumbhare et al. (1983) to standardize production characteristics of different farms with different species of animals. Different herd size category farms (small, medium and large) are post-stratified on the basis of milch SAUs using **cumulative frequency of the square root technique**. Sample households that have herd size from 1 to 2.99 are considered as small; 3 to 5.99 as medium and 6 and above are considered as large farms. It is seen from Table 1 that of the total number of sample households, 92, 82 and 71 number of sample farmers are administered with questionnaires from Barpeta, Sonitpur and Karbi Anglong district respectively. In Barpeta, the small, medium and large adopters constitute 31.52, 21.74 and 5.43 per cent of the total selected sample respondents in the district respectively; whereas, 31.52 and 9.78 per cent sample

Table 5.1: Distribution of Different Herd Size Category Sample Households across Groups and across Districts

Herd Size Category	No. of Households		
	Barpeta	Sonitpur	Karbi Anglong
Adopter			
Small	29 (31.52)	23 (28.05)	6 (8.45)
Medium	20 (21.74)	18 (21.95)	11 (15.49)
Large	5 (5.43)	2 (2.44)	23 (32.39)
Overall	54 (58.70)	43 (52.44)	40 (56.34)
Non-adopter			
Small	29 (31.52)	18 (21.95)	12 (16.90)
Medium	9 (9.78)	20 (24.39)	12 (16.90)
Large	0 (0.00)	1 (1.22)	7 (9.86)
Overall	38 (41.30)	39 (47.56)	31 (43.66)
Total	92 (100)	82 (100)	71 (100)

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to column total

farmers are selected from small and medium non-adopters respectively. Likewise, of the 52.44 per cent adopter farmers in Sonitpur district, Small, medium and large farmers respectively form 28.05, 21.95 and 2.44 per cent of sample respondents, while, 29.95, 24.39 and 1.22 per cent constitute small, medium and large non-adopters respectively. Because of the lower intensity of dairying in Karbi Anglong district, number of sample farmers (both adopter and non-adopter) selected for surveying are relatively less (71 households) compared to Barpeta and Karbi Anglong district. The small (8.45 percent), medium (15.49) and large (32.39) farmers constitute 40 adopters (56.34 per cent) and 31 non-adopters (43.66 per cent) in Karbi Anglong district. Because of the concentration of large commercial dairy farms with crossbred cattle in selected peri-urban pockets of Karbi Anglong district, number of large crossbred adopters selected are relatively found to be higher (32.39 per cent) compared to large adopters in Barpeta and Sonitpur district (see Table 5.1).

5.2. Milk Productivity, Lactation and Reproduction Characteristics of Cattle and Input-Output Relation in Milk Production

5.2.1. Milk Productivity of Crossbred and Indigenous Cattle

Based on the analyses of secondary data in chapter three, it is found that there remain sizable differences in per day milk productivity between crossbred and indigenous cattle. Lactation productivity difference between breeds based on *t*-tests (two tailed) is presented in Table 5.2. There is found to be significant difference in milk productivity per lactation between the

Table 5.2: Lactation Productivity of the Dairy Animals for Different Herd Size Categories across Groups

Farm type	Crossbred (litre/milch SAU)	Indigenous (litre/milch SAU)	Difference
Overall	860.76 (48.13)	324.09 (21.41)	536.67*** (57.46)
Small	1029.22 (86.05)	402.71 (33.21)	626.51*** (91.65)
Medium	697.19 (56.14)	223.09 (18.78)	474.10*** (63.78)
Large	802.25 (97.10)	324.09 (21.41)	536.67*** (57.46)

Source: Author's estimation based on field survey data

Notes: Figures in parentheses indicate standard error;
*** indicate significant at 1% probability level

two breeds for all size category farmers pointing out that crossbred cattle yields approximately 537 liters ($p < 0.01$) of more milk per lactation than the non-descript cattle. Table 5.2 further shows that according to different size class farmers crossbreds owned by smallholders are relatively high milk yielding than the local cattle owned by small farmers which shows that the difference is 626.51 litres ($p < 0.01$). In section 5.2.3, factors that affect productivity are discussed in a linear production function approach for both the breeds (crossbred and non-descript)

5.2.2. Lactation and Reproductive Characteristics of Crossbred and Indigenous Cattle

Apart from productivity difference between crossbred and indigenous cattle, there are other factors which may help us to consider crossbred cattle as superior breed over indigenous one. Table 5.3 reports these differences between the two breeds under consideration with respect to age of first calving, calving interval and lactation length. In Table 5.3 it is seen that age of first calving of crossbreds in the study sample is relatively much lower than the indigenous breeds. This indicates that farmers with crossbreds have to wait relatively lesser time to get the first calf compared to the farmers with indigenous cattle. The age of first calving for crossbreds, on average, across size groups of farmers is 31 months compared to almost 46 months². This implies that a farmer with crossbreds has to rear on average around 15 months less to get the first calf than a farmer rearing indigenous cattle which may have implications on conservations of feed and fodder resources and economy in farm management activities. Some of the studies such as Lalwani (1987), Rao et al. (1995) provide similar justification on the superiority of crossbreds over indigenous breeds. However, there is not any notable difference in the age of first calving between the two breeds across groups (See Table 5.3).

Differences between the two breeds in terms of calving interval and lactation length explain that the calving interval is shorter for crossbred cattle compared to indigenous ones, while lactation length of crossbred cattle is relatively much longer than indigenous cattle. It is found from Table 5.3 that calving interval for the overall crossbred cattle is 427.71 days against 530.56 days of indigenous breed. With respect to lactation length, crossbreds give

milk for an average period of 277.23 days compared to 233.06 days. It is noted that for the large farmers the differences in calving interval and lactation length between the two types of animals is more acute with 159.25 and 53.25 days respectively. Interaction with the farmers during the field survey makes the researcher know that the balanced feeding and effective management of the animals, especially crossbreds are the important determining factors to gain efficiency even within groups with regards to lactation and reproduction characteristics of the animals.

Table 5.3: Lactation and Reproductive Characteristics of the Dairy Animals for Different Herd-size Categories across Groups

Farm type	Age of first calving (Months)		Calving interval (Days)		Lactation length (Days)	
	Crossbred	Indigenous	Crossbred	Indigenous	Crossbred	Indigenous
Overall	30.90	45.69	427.71	530.56	277.23	233.06
Small	31.82	46.73	416.48	530.56	284.22	231.86
Medium	30.45	44.15	444.49	520.98	275.20	238.54
Large	29.87	46.00	422.00	581.25	267.00	213.75

Source: Field Survey, 2015-16

5.2.3. Functional Relationship between Input and Output in Milk Production

For the empirical estimation of the production function using input-output data of milk production among the sample farmers separately for crossbred and indigenous cattle, following linear form of the Cobb-Douglas production function has been considered.

$$\ln Y_i = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \mu_i \quad (5.1)$$

Where,

Y_i = value of milk production per day per milch SAU

β_0 = constant

$\beta_1 - \beta_5$ = coefficients of the variables

X_1 = Value of green fodder fed per day per milch SAU

X_2 = Value of dry fodder fed per day per milch SAU

X_3 = Value of concentrate fed per day per milch SAU

X_4 = Value of labour hour spent per day per milch SAU

X_5 = Miscellaneous cost incurred per day per Milch SAU

μ_i = Standard error term

The results of the OLS estimates of production function are presented in Table 5.4 separately for crossbred and indigenous cattle and for crossbred and indigenous combined (pooled). Table 5.4 reports that the models have a good fit with high R^2 value. Based on the regressions it has been found that concentrate is the most important input to significantly affect the productivity of crossbred and indigenous cattle followed by dry fodder. It shows that one per cent increase in the value of concentrate fed to the animal leads to 0.40 and 0.13 per cent increase in the value of milk production per day per standard animal unit of crossbred and indigenous cattle respectively. This indicates that feeding of concentrate has higher positive elasticity of milk production. Dry fodder is the next important factor to have statistically significant ($p < 0.01$) relationship between the value of dry fodder fed to the animal and rise in milk productivity. A one per cent increase in the value of dry fodder fed to the animal leads to 0.19 and 0.25 per cent increase in the value of milk production for crossbred and indigenous cattle respectively. Imputed value of the labour hour spent for indigenous cattle exerts a positive and statistically significant relationship with the productivity of cattle. However the same is not found to be significant to influence productivity of crossbred cattle. The reason may be that since the average herd size of standard milch animal unit of crossbreds is higher than the average herd size of the indigenous cattle (5.69 milch SAU of crossbreds compared to 2.65 milch SAU of Indigenous breed), labour hour spent per crossbred milch SAU on farming operations may be proportionately less compared to indigenous cattle in the study sample. Value of miscellaneous factors such as expenditures on medicine, doctor's fee, vitamin, calcium and minerals and cost incurred on artificial insemination (AI)/natural service (NS) are found to affect significantly and positively the productivity of both crossbred and indigenous cattle with an extent of 0.23 and 0.22 per cent respectively. Value of green fodder fed per milch SAU is not found to be statistically significant to affect productivity of crossbred cattle and it is negatively associated with the productivity of indigenous cattle (see Table 5.4). The reason may be that for a large number of farmers in the sample households access to green fodder is constrained by seasonality due to flood and non-availability of land due to sowing of paddy fields for which productivity is affected in case of crossbred cattle. On the other

hand, negative association implicates prevailing problem of overfeeding in case of indigenous cattle. Similar findings are reported by Kumar (2001) in his study conducted in Meerut district of Uttar Pradesh.

For the pooled regression all the factors have a positive and significant relation with the productivity of crossbred cattle. It is seen that irrespective of breeds, one per cent increase in feeding of green fodder, dry fodder and concentrate may lead to increase in the value of output in the magnitude of respectively 0.03, 0.25 and 0.31 per cent per milch SAU/day. Table 5.4 thus reports that productivity increase in crossbred cattle is highly influenced by feeding of concentrate followed by miscellaneous cost incurred and feeding of dry fodder. The finding of the study is consistent with Paul and Chandel (2010) and Rais Uddin et al. (2007).

Table 5.4: OLS estimates of milk production functions

Variable	Pooled		Crossbred cattle		Non-descript cattle	
	β - value	"t" Value	β - value	"t" Value	β - value	"t" Value
Intercept	1.042*** (0.686)	15.20	1.038*** (0.830)	12.51	0.934*** (0.109)	8.54
Green fodder	0.0295*** (0.311)	0.95	0.042 (0.035)	1.21	-0.020 (0.059)	-0.33
Dry fodder	0.249*** (0.368)	6.77	0.195*** (0.044)	4.41	0.250*** (0.064)	3.88
Concentrate	0.305*** (0.033)	9.22	0.402*** (0.045)	8.88	0.133** (0.055)	2.44
Labour	0.119** (0.052)	2.30	0.082 (0.063)	1.30	0.276*** (0.089)	3.09
Miscellaneous	0.249*** (0.035)	7.11	0.228*** (0.049)	4.64	0.217*** (0.055)	3.97
R ²	0.7922		0.8079		0.6487	
F-value	182.22***		110.17***		37.67***	
Number of observation	245		137		108	

Source: Author's estimation based on field survey data

Notes: Figures in parentheses indicate standard error;

** and *** indicate significant at 5% and 1% probability level respectively

5.3. Economics of Dairying and Determinants of Profitability in Dairying

5.3.1. Economics of Dairying

The economics of dairying based on operational cost and value of milk production among the sample farmers of various farm size categories with and without imputations of costs and returns are presented respectively in Table 5.5 and Table 5.6. In Table 5.5, various operational costs and income from milk production are presented by taking the imputed value of domestically available fodder resources, imputed cost of family labour, and imputed value of cow dung and on the income side the imputed value of domestically consumed milk. This is compared with the dairy business based on actual costs (without imputations) presented in Table 5.6, where only paid out cost components are incorporated following Kassie et al. (2011) along with the income received from the milk sale. It is seen from Table 5.5 that operational costs incurred per standard animal unit/day is Rs 82.44 for overall adopters and Rs 54.54 for non-adopters. Adjusting the total operating costs for the imputed value of cow dung produced in the farm, we arrived at net operating costs which are estimated at Rs 75.61/day/milch SAU for adopters and Rs 47.95/day/milch SAU for non-adopters. For both adopters and non-adopters the net operational costs decreased with increase in farm size. It is seen from Table 5.5 that in case of adopters, 51.20 per cent of the total operating costs per standard animal unit/day are constituted by the labour cost (hired+family labour), while for non-adopters this figure is even higher (68.01 per cent). Following this, feed and fodder cost is the next dominant cost component for both adopters (44.20 per cent) and non-adopters (29.35 per cent) across farm size groups.

Higher productivity of crossbred cattle realizes much higher net return from milk production for adopters compared to non-adopters. It is found that net return from milk production for adopters is Rs 37.02/day/milch SAU compared to Rs 2.62 for non-adopters (Table 5.5). According to farm size category, large farmers have higher net returns for both adopters (Rs 50.28/day/milch SAU) and non-adopters (Rs 14.32/day/milch SAU) group. It can be estimated that for the average size of cattle holdings of adopters (5.69 milch SAU), the

annual income is expected to be Rs. 76,884.99 against the income of non-adopters (Rs 2534.20) for the average size of cattle holding of 2.65 milch SAU.

Table 5.5: Cost and Return of Milk Production for Different Herd Size Categories across Groups

Particulars	Adopter				Non-adopter			
	Small (N=58)	Medium (N=49)	Large (N=30)	Overall (N=137)	Small (N=59)	Medium (N=41)	Large (N=8)	Overall (N=108)
Operational cost (Rs/day/milch SAU)								
Green Fodder	2.55 (2.41)	2.01 (2.95)	2.18 (3.58)	2.27 (2.75)	1.32 (1.87)	1.28 (3.63)	0.76 (2.16)	1.27 (2.33)
Dry fodder	11.45 (10.82)	7.32 (10.75)	6.41 (10.54)	8.87 (10.76)	8.74 (12.37)	4.06 (11.52)	4.13 (11.72)	6.62 (12.14)
Concentrate	28.58 (27.02)	21.67 (31.83)	24.90 (40.95)	25.30 (30.69)	9.67 (13.69)	5.95 (16.89)	7.89 (22.39)	8.12 (14.89)
Feed and fodder	42.58 (40.25)	31.00 (45.54)	33.49 (55.07)	36.44 (44.20)	19.73 (27.93)	11.29 (32.05)	12.78 (36.28)	16.01 (29.35)
Labour cost	58.35 (55.16)	34.14 (50.15)	24.30 (39.96)	42.21 (51.20)	49.10 (69.51)	22.94 (65.11)	21.11 (59.92)	37.09 (68.01)
Cost on AI/NS	0.49 (0.46)	0.51 (0.75)	0.62 (1.02)	0.53 (0.64)	0.006 (0.008)	0.00 (0.00)	0.00 (0.00)	0.004 (0.007)
Veterinary expenses	4.36 (4.12)	2.42 (3.56)	2.50 (4.11)	3.26 (3.95)	1.80 (2.55)	0.91 (2.58)	1.33 (3.78)	1.43 (2.62)
Total veterinary cost	4.85 (4.58)	2.93 (4.30)	3.12 (5.13)	3.79 (4.60)	1.81 (2.56)	0.91 (2.58)	1.33 (3.78)	1.43 (2.62)
Total operational Cost	105.78 (100)	68.07 (100)	60.81 (100)	82.44 (100)	70.64 (100)	35.23 (100)	35.23 (100)	54.54 (100)
Return from cow dung (Rs)	6.88	6.91	6.76	6.83	6.45	6.51	6.78	6.59
Net operational cost (Rs)	98.90	61.16	54.05	75.61	64.19	28.72	28.45	47.95
Return from dairying								
Daily milk production (litres)	8.01	11.99	34.07	15.14	2.30	3.32	8.19	3.12
Average sale price of milk (Rs/litre)	36.38	37.26	36.17	36.65	38.49	36.70	34.00	37.47
Return from milk production (Rs/day/milch SAU)	134.70	91.56	104.33	112.63	63.64	33.27	42.77	50.57
Net return from milk production (Rs/day/milch SAU)	35.80	30.4	50.28	37.02	-0.55	4.55	14.32	2.62

Source: Field survey, 2015-16

Note: Figures in parentheses indicate percentage to total operational cost

Based on actual value of operational cost and return from milk sale, the economics of milk production is presented in Table 5.6. It is found that the total paid out operational cost is Rs

36.50/day/milch SAU for adopters against Rs 14.37 for non-adopters. Table 5.6 also shows that of the total operational costs incurred for each standard animal unit, cost on feed and fodder constitute the highest share for both adopters (86.36 per cent) and non-adopters (83.58 per cent). Among the remaining cost components, share of total veterinary costs (Costs on AI, medicines, vitamins and calcium, minerals and doctor's fees etc.) incurred on standard animal unit is ranked as second with 10.38 per cent for adopters and 9.98 for non-adopters. Hired labour cost constitutes a very minute share of 3.29 per cent for adopters and 6.40 per cent for non-adopters. It has also been seen that the percentage share of labour cost decreased with increase in herd size for both the adoption groups. The pattern is consistent with the finding of the study carried out by Bardhan and Sharma (2012) on comparative cost of milk production between members and non-members of cooperative in Kumaon region of Uttarakhand. The net return from milk sale per standard animal per day is estimated at Rs 61.60 for adopters and Rs 19.22 for non-adopters. According to farm size category, small farmer adopters have net return of Rs 69.62/day/milch SAU which is higher than the average net return of overall adopters. Similar is the case for non-adopters as well. Thus, given the actual net return per standard animal per day of adopters and non-adopters, the annual income for the average farm size households is estimated at Rs 1,27,933.96 for adopters and Rs 18,590.55 for non-adopters.

Table 5.6: Cost and Return of Milk Production for Different Herd Size Categories across Groups

Particulars	Adopter				Non-adopter			
	Small (N=58)	Medium (N=49)	Large (N=30)	Overall (N=137)	Small (N=59)	Medium (N=41)	Large (N=8)	Overall (N=108)
Operational cost (Rs/day/milch SAU)								
Green Fodder	0.02 (0.05)	0.04 (0.13)	0.13 (0.38)	0.05 (0.14)	0.00 (0.00)	0.84 (8.41)	0.00 (0.00)	0.03 (0.21)
Dry fodder	7.83 (17.98)	4.50 (15.18)	5.68 (16.67)	6.17 (16.90)	4.61 (26.24)	2.79 (27.93)	3.78 (28.64)	3.86 (26.86)
Concentrate	28.58 (65.63)	21.67 (73.09)	24.90 (73.06)	25.30 (69.32)	9.67 (55.04)	5.95 (59.56)	7.89 (59.77)	8.12 (56.51)
Feed and fodder	36.43 (83.65)	26.21 (88.40)	30.71 (90.11)	31.52 (86.36)	14.28 (81.27)	9.58 (95.90)	11.89 (90.08)	12.01 (83.58)
Labour cost (hired labour only)	2.27 (5.21)	0.51 (1.72)	0.27 (0.79)	1.20 (3.29)	1.48 (8.42)	0.26 (2.60)	0.20 (1.52)	0.92 (6.40)
Cost on AI/NS	0.49 (1.13)	0.51 (1.72)	0.62 (1.82)	0.53 (1.45)	0.007 (0.04)	0.00 (0.00)	0.00 (0.00)	0.004 (0.03)
Veterinary expenses	4.36 (10.01)	2.42 (8.16)	2.50 (7.34)	3.26 (8.93)	1.80 (10.24)	0.91 (9.11)	1.33 (10.08)	1.43 (9.95)
Total veterinary cost	4.85 (11.14)	2.93 (9.88)	3.12 (9.15)	3.79 (10.38)	1.81 (10.30)	0.91 (9.11)	1.33 (10.08)	1.434 (9.98)
Total operational Cost	43.55 (100)	29.65 (100)	34.08 (100)	36.50 (100)	17.57 (100)	9.99 (100)	13.20 (100)	14.37 (100)
Return from cow dung (Rs)	2.03	2.56	2.34	2.33	1.94	1.76	2.05	1.93
Net operational cost (Rs)	41.52	27.09	31.74	34.17	15.63	8.23	11.15	12.44
Return from dairying								
Daily milk Sale (litres)	6.69	10.14	31.82	13.43	1.42	2.34	7.13	2.19
Average sale price of milk (Rs/litre)	36.38	37.26	36.17	36.65	38.49	36.70	34.00	37.47
Return from milk sale (Rs/day/milch SAU)	111.14	77.03	96.66	95.77	37.09	22.74	37.38	31.66
Net return from milk sale (Rs/day/milch SAU)	69.62	49.94	64.92	61.60	21.46	14.51	26.23	19.22

Source: Field survey, 2015-16

Notes: Figures in parentheses indicate percentage to total operational cost

The comparison of Table 5.5 and Table 5.6 explains that imputed value of family labour estimated at par with cost on hired labour brings the major differences in the net returns from dairying for the two different cases (with and without cost/return imputations). During the primary survey it is observed that sizable sample farmers carry out dairying activities by engaging family labor leading to underestimation of operational costs. In other words, if cost

of family labour is excluded from the total operational costs then there is significant increase in net returns from dairying. This finding is consistent with several studies such as Bardhan and Sharma (2012), Saha and Gupta (2000), Kumar and Dhaka (1999) etc. Again, in a mixed-farm system, internal input flow also reduces actual costs if the imputed value of the domestically available fodder resources (green and dry fodder) is excluded. From Table 5.5 and Table 5.6, it is found that the share of green fodder cost in the imputed total operational cost decreased from 2.75 per cent to 0.14 per cent in the actual cost for overall adopters and from 2.33 per cent to 0.21 per cent for non-adopters. Likewise, in case of dry fodder also there is decline in absolute cost of Rs 2.7 per standard animal unit/day for both adopters and non-adopters³. Thus, based on the finding it can be summarized that internal flow of input in a mixed farm system and operating dairy business using family labour may incentivize farmers to go for dairying due to higher net returns. In the next section, an attempt has been made to identify factors influencing profitability of dairy farming in the two different estimates of net return calculations among the sample farmers.

5.3.2. Factors Determining Profitability (Net returns/milch SAU) in Milk Production

A multiple regression equation of the following form is fitted to identify the factors that significantly influence profitability in milk production (net returns/milch SAU).

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} D_1 + \beta_{14} D_2 + \beta_{15} D_3 + \beta_{16} D_4 + \beta_{17} D_5 + \beta_{18} D_6 + \mu \quad (5.2)$$

Where,

Y = Net returns/SAU/day (Rs)

β_0 = constant

$\beta_1 - \beta_{18}$ = coefficients of the independent variables

X_1 = Age of household head (years)

X_2 = Education of the household head (Numbers of years of schooling or education completed)

X_3 = Family size (number of family members in a household)

X_4 = Landholding size (hectare)

X_5 = Operational holding allotted for fodder cultivation (hectare)

X_6 = Distance to nearest village market (km)

X_7 = Years of starting the dairy farm (number of years)

X_8 = Herd size (total number of SAU)

X_9 = Sale price of milk (Rs)

X_{10} = Proportion of milk produced in the farm that is sold (per cent)

X_{11} = Labour cost (actual/actual+imputed) (in Rs)

X_{12} = Feed and fodder cost (actual/actual+imputed) (in Rs)

D_1 = Dummy for access to credit ($D_1 = 1$ if the household had accessed credit during the period of five years preceding the survey; $D_1 = 0$, otherwise)

D_2 = Dummy for membership of Dairy Cooperative Society (DCS) ($D_2 = 1$ if the household head is a member of DCS; $D_2 = 0$, otherwise)

D_3 = Dummy to capture the effect of extension contact ($D_3 = 1$ if the household had contacted any extension agent during 12 months preceding the survey; $D_3 = 0$, otherwise)

D_4 = Dummy for off-farm income ($D_4 = 1$ if the household has any off-farm sources of income; $D_4 = 0$, otherwise)

D_5 = Location dummy to represent district Barpeta ($D_5 = 1$ if households falls under Barpeta district; $D_5 = 0$, otherwise)

D_6 = Location dummy to represent district Sonitpur ($D_6 = 1$ if households falls under Sonitpur district; $D_6 = 0$, otherwise)

μ = Standard error term

For the explanatory variables mentioned above, two separate models (model 1 and model 2) are estimated. In model 1, dependent variable, i.e., net returns per standard animal unit/day is based on the value of actual paid out costs (on the basis of Table 5.6); while in model 2, dependent variable is the estimates of actual plus imputed costs of domestically available fodder resources and family labour (based on Table 5.5). Among the variables considered in the regression models, age of the household head, education of household head, family size,

land holding, fodder cultivation, access to credit, membership of DCS, herd size, extension contact, off-farm income, price received on the sale of milk, proportion of milk sold, actual/imputed value of feed and fodder fed per standard animal unit are hypothesized to have positive relation with the dependent variable. On the other hand, variables such as distance to nearest village market and actual/imputed cost on labour are expected to have negative relation with the profit from dairying. The remaining variable, years of starting the dairy farm may have either positive or negative relation with the dependent variable. The reason being that the more number of years with the dairy farm may implicate better experience (+) or new farms are more profit oriented with innovative production methods (-). The inferences with regards to district dummy variables are in relation to the excluded dummy (Karbi Anglong as reference district). The fitted function is estimated using OLS technique in STATA 14.

The results of the multiple regression analysis carried out to identify the factors significantly affecting the profitability in milk production (both with and without imputations) are presented in Table 5.7. Table 5.7 shows that a high R^2 value of 0.7274 in model 1 and 0.7761 in model 2 and a corresponding significant F-value of 33.50 and 43.52 respectively indicate a better fit of the models. In both the models explanatory variables are checked for problems of multicollinearity and it is found that there is not any multicollinearity problem as the VIF values are less than 5 (mean VIF for model 1 and model 2 are 1.50 and 1.56 respectively) (See Table 5.8). It is seen that the relation of most of the significant variables with the dependent variable are in accordance with the hypothesized sign in both the models. In model 1, variables that affect actual profitability of dairying positively and significantly are landholding ($p < 0.05$), access to credit ($p < 0.10$), membership of DCS ($p < 0.10$), sale price of milk ($p < 0.01$), proportion of milk sold ($p < 0.01$), and actual value of feed and fodder fed to the animal ($p < 0.01$), while the only variable that has statistically significant negative relation with the dependent variable is years of starting the dairy farm ($p < 0.10$). This implies that a one hectare increase in landholding leads to 37.86 per cent rise in the profitability of dairying. Similarly, a farmer who has access to credit and have membership of DCS, his chances of increase in profit is more by 12.45 and 11.97 per cent respectively. Again, as the sale price of milk increases by one rupee and proportion of milk sold out of the total milk production increases by one per cent, there may be a highly significant increase in

profitability to the extent of 1.39 and 58.59 per cent respectively. Table 5.7 further shows that actual value of feed and fodder fed to the animal is indicative of nutritional supply which may lead to higher profitability. On the basis of the results of the multiple regressions it is found that increase in the actual value of feed and fodder of one rupee equivalent fed to the animal increases profitability by 1.95 per cent. The model also shows that the new farms are more profitable than the older farms. It shows that one additional year reduction in the duration of operation of dairy farming leads to 0.35 per cent more profit. Thus, there is various market and non market factors that are significantly found to influence actual profit from dairying (see Table 5.7).

Factors influencing profitability in milk production in model 2 indicates that like model 1 most of the statistically significant variables have expected sign. This implies that variables such as herd size, contact with extension agent, off-farm income, price received for the milk sold and proportion of milk sold positively and significantly affects profitability from dairying, while variable, the imputed labour cost has significant expected relation with the dependent variable. The highly significant and negative relation of imputed labour cost with dependent variable implies that imputations of the family labour cost are the important determinant of the differences between the two models. This may give similar implication for family size to have a negative significant relation (model 2 in Table 5.7). The households that have higher family size also have higher adult equivalent to work in the dairy farm. Adjustment of the opportunity cost of the family labour through imputations at the level of the cost of hired labour may exert a negative effect on the profitability of milk production. Households having devoted land for fodder cultivation also have a negative and significant effect on the profitability. This implies that these households feed greater amount of green fodder compared to other farmers and incorporating the imputed cost of green fodder reduces profit margin significantly. One hectare increase in the area of land devoted for fodder cultivation reduces profit margin by 8.60 per cent. Unlike model 1, herd size and extension contact significantly and positively influences farm profitability of milk producers. Farm households with the increase of one additional standard animal unit their probability of profit margin increases by 3.11 per cent ($p < 0.01$). Again, the farmers that had contacted extension agent during last 12 months preceding the survey are seemed to better guide the farmers to have better farm management practices that may lead to significantly

higher farm profit ($p < 0.05$). Farm households with off-farm sources of income may have capital base which can be reinvested in the dairy farm and also have ability to meet easily the recurring expenses of farm management. This helps strengthening of dairy business and a higher profit margin. Model 2 in Table 5.7 show that farmers with off-farm income may have 3.94 per cent ($p < 0.05$) higher profitability of milk production. It has also been found that increase in sale price of milk by one rupee and one per cent increase in the proportion of milk sold in the total milk production may lead to 0.72 and 8.52 per cent increase in the farm profitability of milk producers respectively. Both model 1 and model 2 are checked for influence of location fixed effects in terms of district dummy. It is seen that model 1 do not represent having any significance of location fixed effect. But in model 2, Sonitpur district with reference to Karbi Anglong has significance in raising profitability in dairying.

Overall, it is found that although the dependent variable in the two models in Table 5.7 is the estimation of net returns in milk production, their magnitude of net returns differs from one another with or without consideration of imputed value of domestically consumed milk. There are also differences in certain explanatory variables associated with cost of dairying affecting profitability (See Table 5.7). Identification of factors determining profitability of milk production is guided by inclusion (or exclusion) of cost and return imputation which brings differing direction and significance level of independent variables affecting the dependent variables in model 1 and model 2.

Table 5.7: Factors Influencing Profitability in Dairying [Dependent Variable: Net returns from dairying (Rs/milch SAU/day)]

Variables	Model 1 (Without imputations)		Model 2 (With imputations)	
	β - values	<i>t</i> -Value	β - values	<i>t</i> -Value
Intercept	-85.239*** (20.041)	-4.25	-41.267*** (7.277)	-5.67
Age of the HH head	0.185 (0.227)	0.82	0.055 (0.080)	0.69
Education of HH head	0.052 (0.563)	0.09	0.109 (0.199)	0.55
Family size	-0.672 (1.002)	-0.67	-0.719** (0.353)	-2.04
Land holding (hectare)	37.863** (16.76)	2.26	8.604 (5.896)	1.46
Fodder cultivation (hectare)	2.413 (2.474)	0.98	-3.456*** (0.871)	-3.97
Access to credit (Dummy)	12.452* (6.672)	1.87	-1.047 (2.350)	-0.45
Membership of DCS (Dummy)	11.970* (6.369)	1.88	-0.191 (2.251)	-0.08
Distance to nearest village market (in Km)	-0.646 (1.547)	-0.42	-0.816 (0.549)	-1.48
Years of starting the dairy farm (years)	-0.351* (0.202)	-1.74	-0.001 (0.070)	-0.01
Herd Size (total SAU)	-0.351 (0.391)	-1.01	3.114*** (0.141)	22.06
Contact with Extension agent (Dummy)	7.793 (7.054)	1.10	6.219** (2.509)	2.48
Off-farm Income (Dummy)	2.779 (5.204)	0.53	3.940** (1.837)	2.15
Sale price of milk (Rs)	1.393*** (0.396)	3.52	0.722*** (0.139)	5.19
Proportion of milk sold	58.598*** (11.566)	5.07	8.528** (3.979)	2.14
Actual Labour cost (Rs/SAU/day)	2.343 (1.668)	1.40	-	-
Imputed Labour cost (Rs/SAU/day)	-	-	-0.129*** (0.044)	-2.96
Actual feed and fodder cost (Rs/SAU/day)	1.951*** (0.157)	12.46	-	-
Imputed feed and fodder cost (Rs/SAU/day)	-	-	-0.002 (0.059)	-0.04
Barpeta (Dummy)	1.131 (7.066)	0.68	3.357 (2.530)	1.33
Sonitpur (Dummy)	-4.889 (7.211)	-0.68	6.204** (2.539)	2.44
R ²		0.7274		0.7761
F-value		33.50***		43.52***
No. of observations		245		245

Source: Author's estimation based on field survey data

Notes: Figures in parentheses indicate standard error;

***, **, and * indicate significant at 1%, 5% and 10% probability level

Table 5.8: Variance Inflation Factor of the Explanatory Variables

Variables	Model 1		Model 2	
	VIF	Tolerance	VIF	Tolerance
Age of the HH head	1.54	0.45	1.55	0.64
Education of HH head	1.35	0.74	1.36	0.73
Family size	1.23	0.81	1.22	0.82
Land holding (hectare)	1.22	0.82	1.21	0.83
Fodder cultivation (hectare)	1.32	0.75	1.32	0.76
Access to credit (Dummy)	1.18	0.85	1.17	0.85
Membership of DCS (Dummy)	1.64	0.61	1.64	0.61
Distance to nearest village market (in Km)	1.21	0.82	1.23	0.82
Years of starting the dairy farm (years)	1.68	0.59	1.63	0.61
Herd Size (total SAU)	1.34	0.74	1.40	0.71
Contact with Extension agent (Dummy)	1.42	0.70	1.44	0.69
Off-farm Income (Dummy)	1.24	0.80	1.24	0.80
Sale price of milk (Rs)	1.43	0.70	1.42	0.70
Proportion of milk sold	1.62	0.62	1.54	0.65
Actual Labour cost (Rs/SAU/day)	1.42	0.70	-	-
Imputed Labour cost (Rs/SAU/day)	-	-	1.91	0.52
Actual feed and fodder cost (Rs/SAU/day)	1.79	0.55	-	-
Imputed feed and fodder cost (Rs/SAU/day)	-	-	2.41	0.41
Barpeta (Dummy)	2.22	0.45	2.29	0.44
Sonitpur (Dummy)	2.20	0.46	2.19	0.46
Mean VIF	1.50		1.56	

Source: Author's estimation based on field survey data

5.4. Crossbreeding of Cattle and Employment in Dairying

Dairy is basically a labour intensive enterprise and uses surplus family labour and attached labour (Sidhu and Bhullar, 2004). Improved farm management with the rearing of crossbred cattle leads to higher milk productivity which indirectly also leads to higher employment level. Various empirical studies such as Chauhan and Kundus (2005), Singh (1997) etc. have established that introduction of high yielding crossbred milch animals and relatively better management of farm operations have led to increase in human labour employment along with increase in household income. In the present study, based on Table 5.9 and Table 5.10 an attempt is made to provide a comparative estimates on the scope of employment in the improved milk production system (rearing of crossbred cattle with commercial orientation) in relation to traditional system (rearing of non-descript cattle) on the sample farmers in

Assam. A detailed breakup of the estimated labour use figure in terms of farm size, gender and according to various farming operations have also been presented in Table 5.9 and Table 5.10. In Table 5.9, disaggregated labour use estimates are presented separately for male and female workers in the household across farm operations and farm types. It points out that there is an increase in the overall use of labour (person days/month) with the increase in farm size. This pattern of labour use applies to both for male and female. However, the differences in the engagement of male and female workers in case of small farms across farm operations are relatively much less (5.72 female person days/month vis-à-vis 8.56 male person days/month) compared to large farms where labour use of male person days/month is three times more than the female person days. The findings have contradicted with Akhter et al. (2002) in their study conducted in Bareilly district of Uttar Pradesh where it is claimed that the contribution of women is more than that of men in performing animal husbandry activities. It is also found that there are variations in the use of labour hour between male and female groups according to various operations of dairying. Operations like feeding and grass collection and cleaning of cattle shed and washing of animals engage relatively more female labour than activities like marketing of milk. As far cleaning activities are concerned, female labourers in the small farm size category share more than 50 per cent of the total labour hour used. However, with the increase in the size of farm, commercialized farming takes the motion with high yielding crossbred cattle adoption and in the process male labourers are gradually found to be engaged towards a full time worker. This has resulted in the decline in share of female labourers for all the farming operations (see Table 5.9). It is also observed that operations like marketing of milk where male labourers are engaged proportionately much more across farm sizes than the other activities under consideration. The findings in the study are consistent with Chauhan and Kundu (2005)

Table 5.9: Labour Use in Various Dairying Activities across Different Farm Size and Gender Groups. (Person days/month)

Feeding and Grass Collection			
Farm size	Male	Female	Total
Small	3.14 (52.68)	2.81 (47.15)	5.96 (100)
Medium	5.83 (61.37)	3.54 (37.26)	9.50 (100)
Large	12.04 (67.60)	5.77 (32.40)	17.81 (100)
Overall	5.51 (60.88)	3.54 (39.12)	9.10 (100)
Milking			
Small	0.53 (60.23)	0.35 (39.77)	0.88 (100)
Medium	0.95 (76.61)	0.29 (23.39)	1.24 (100)
Large	2.63 (92.28)	0.22 (7.72)	2.85 (100)
Overall	1.01 (76.52)	0.30 (22.72)	1.32 (100)
Marketing of milk			
Small	1.80 (97.30)	0.05 (2.70)	1.85 (100)
Medium	1.51 (94.97)	0.08 (5.03)	1.59 (100)
Large	4.62 (100)	0.00 (0.00)	4.62 (100)
Overall	2.13 (97.71)	0.06 (2.75)	2.18 (100)
Cleaning of Cattle Sheds and Washing of animal			
Small	2.22 (49.01)	2.31 (50.99)	4.53 (100)
Medium	3.12 (52.35)	2.85 (47.82)	5.96 (100)
Large	5.64 (63.01)	3.31 (36.98)	8.95 (100)
Overall	3.08 (53.66)	2.66 (46.34)	5.74 (100)
Overall			
Small	8.56 (59.99)	5.72 (40.01)	14.27 (100)
Medium	12.25 (64.61)	6.71 (35.39)	18.96 (100)
Large	27.66 (74.66)	9.39 (25.34)	37.05 (100)
Overall	12.87 (65.90)	6.65 (34.10)	19.53 (100)

Source: Field Survey, 2015-16

Notes: Figures in parentheses indicate percentage to total

Differences in labour use between adopter and non-adopter (of crossbred cattle) category of farmers across farm size and farm operations are presented in Table 5.10. As stated earlier, the primary objective to disaggregate the use of labour between adopter and non-adopter is to highlight the employability prospect of crossbreeding technology adoption. The differences in the use of labour (person days/month) between adopter and non-adopter is worked out according to overall farm and milch standard animal unit (see Table 5.10). The consideration of labour use according to per milch SAU is to provide the estimate addressing the heterogeneity in the number of cattle holding within each farm size category. Table 5.10 shows that there is significantly higher use of labour per farm for adopter groups

for all farm size categories and farm operations. It is found that adoption of crossbred cattle significantly leads to 13.97 ($p<0.01$) more person days/month compared to non-adopter. The increase in labour use is the highest for large farms (19.65 person days/month; $p<0.05$) followed by medium category farms (11.88 person days/month; $p<0.01$). Considering the labour use per standard animal unit, it is found that there is positive but non-significant effect in labour use per milch SAU for crossbred adopters. However, there is statistically significant increase in labour use per milch SAU after adoption of crossbred cattle for small and medium farmers in the magnitude of 1.41 ($p<0.10$) and 1.71 ($p<0.05$) person days/month respectively (Table 5.10). Labour use differences according to farm operations with adoption of new dairy technology, i.e., crossbred cattle indicates that operations like feeding and grass collection leads to statistically significant increase in the use of labour per farm across farm size categories (7.03 person days/month; $p<0.01$). Again, monthly use of labour per milch standard animal unit following adoption of crossbred cattle also increases significantly to the extent of 0.54 person days ($p<0.05$) in feeding and grass collection. According to farm type, the monthly increase of labour use per milch SAU is the highest for the medium category farms (0.99 person days/month; $p<0.01$) followed by small farms (0.73 person days/month; $p<0.10$). Other farm operations such as milking, and cleaning of cattle sheds and washing of animals also exhibits significant increase in the labour use for both farm-wise and milch SAU-wise. Table 5.10 shows that adopter farms have higher labour requirements equivalent to 1.07 person days ($p<0.01$) in milking activities compared to non-adopters and with respect to labour requirements per milch SAU adopter farms require 0.08 person days/month ($p<0.05$). The higher labour hour requirements is due to higher milk productivity of crossbred cattle for which adopter farmers have to milk their cattle relatively for longer duration. Perusal of Table 5.10 also indicates that increase in the labour requirements in milking operations are proportionately more for higher farm sizes.

The next important farm management operations after feeding and grass collection that require a higher amount of labour is the cleaning of cattle sheds and washing of animals. Since crossbred cattle are associated with higher capital investments compared to non-descript cattle and most of the farmers perceive them as being susceptible to disease, they are devoted utmost care and management. This also leads to relatively more use of labour in cleaning and washing operation by the adopter farmers. Table 5.10 shows that monthly use

Table 5.10: Labour Use in Various Dairying Activities across Different Farm size and Adopter Groups. (Person days/month)

Farm size	Labour use/Farm			Labour use/Milch SAU		
	Adopter	Non-adopter	“t” - test	Adopter	Non-adopter	“t” - test
Feeding and Grass Collection						
Small	7.95 (0.614)	3.99 (0.418)	3.964*** (0.741)	3.69 (0.275)	3.96 (0.273)	0.73* (0.387)
Medium	12.48 (1.067)	5.95 (0.467)	6.53*** (1.243)	2.65 (0.210)	1.66 (0.121)	0.99*** (0.255)
Large	19.94 (2.740)	9.85 (1.407)	10.09* (5.403)	1.76 (0.213)	1.49 (0.234)	0.27 (0.432)
Overall	12.10 (0.845)	5.17 (0.342)	7.03*** (0.100)	2.90 (0.159)	2.36 (0.169)	0.54** (0.234)
Milking [#]						
Small	1.78 (0.087)	0.59 (0.055)	0.59*** (0.102)	0.56 (0.047)	0.45 (0.049)	0.11 (0.068)
Medium	1.68 (0.151)	0.77 (0.071)	0.86*** (0.178)	0.35 (0.034)	0.21 (0.017)	0.14*** (0.041)
Large	3.23 (0.436)	1.42 (0.296)	1.82** (0.866)	0.28 (0.034)	0.21 (0.045)	0.07 (0.070)
Overall	1.79 (0.133)	0.72 (0.050)	1.07*** (0.156)	0.42 (0.026)	0.34 (0.030)	0.08** (0.039)
Marketing of milk [#]						
Small	2.40 (0.280)	1.31 (0.207)	1.09*** (0.347)	1.15 (0.152)	1.06 (0.194)	0.09 (0.247)
Medium	1.75 (0.225)	1.408 (0.306)	0.34 (0.373)	0.37 (0.044)	0.38 (0.046)	-0.01 (0.084)
Large	4.90 (1.008)	3.57 (1.567)	1.33 (1.328)	0.48 (0.099)	0.51 (0.215)	0.03 (0.222)
Overall	2.72 (0.280)	1.51 (0.203)	1.20*** (0.363)	0.80 (0.076)	0.76 (0.115)	0.04 (0.133)
Cleaning of Cattle Sheds and Washing of animal						
Small	6.11 (0.511)	2.97 (0.205)	3.137*** (0.547)	2.96 (0.289)	2.21 (0.159)	0.75** (0.329)
Medium	8.04 (0.594)	3.48 (0.250)	4.56*** (0.688)	1.71 (0.122)	0.99 (0.075)	0.72*** (0.150)
Large	10.27 (1.520)	3.99 (0.552)	6.28** (2.980)	0.90 (0.117)	0.60 (0.098)	0.30 (0.234)
Overall	7.71 (0.466)	3.24 (0.154)	4.47*** (0.543)	2.06 (0.149)	1.63 (0.111)	0.43** (0.195)
Overall						
Small	18.77 (1.195)	9.85 (0.686)	8.926*** (1.372)	8.87 (0.606)	7.47 (0.547)	1.41* (0.816)
Medium	24.37 (0.800)	12.49 (1.501)	11.88*** (1.798)	5.19 (0.295)	3.49 (0.189)	1.71*** (0.366)
Large	41.19 (4.229)	21.54 (2.681)	19.65** (8.378)	3.68 (0.325)	3.21 (0.413)	0.47 (0.667)
Overall	25.68 (1.383)	11.72 (0.593)	13.97*** (1.645)	6.42 (0.363)	5.64 (0.340)	0.78 (0.501)

Source: Author's estimation based on field survey data

Notes: Figures in parentheses indicate standard error;

*, ** and *** indicate significant at 10%, 5% and 1% probability level respectively

of person days in cleaning of cattle sheds and washing of animals in the farms of adopters is significantly higher by 4.47 ($p < 0.01$) over non-adopters. Again, the use of monthly person days in the same operation for every standard animal significantly rises by 0.43 ($p < 0.05$). Labour use per farm across farm size in farming operation such as marketing of milk shows significant increase after adoption of crossbreeding technology. However, in marketing of milk there is no significant increase in the labour use per milch SAU after adoption of crossbreeding technology. There is also not any clear pattern in the increase of labour use with the increase in farm size after adoption of crossbreeding technology. The reason may be that relatively larger farmers may find it difficult to sell their produce themselves in the market due to short supply of labour and thus they may prefer to sell it to either private trader that picks up milk from the farmyard or to nearby cooperatives. However, according to Kumar et al. (2010), from vendor and processor's front marketing and processing of milk is one of the important segments of employment in the dairy sector of Assam and accounts for about 10 per cent of the workforce engaged in the dairy sector.

Thus it is seen that crossbreeding technology adoption is associated with increased amount of labour use for various farming activities per farm and per standard animal unit, and there lies heterogeneity in the level of labour use according to farm size and farm operations. Overall increase in the farm employment in dairy farming in the present study is consistent with finding of the study carried out by Sidhu and Bhullar (2004)

Effect of crossbred cattle adoption on labour use according to gender for various farm sizes is presented in Table 5.11. Adoption of crossbred cattle directly leads to significant increase of male and female labour use equivalent to 9.94 and 4.03 person days per month respectively. For the small and medium farms the increase in labour use after adoption of crossbred cattle is significant at 1% probability level for both male and female workers. However, for large farms, there is a significant requirement of services for male labourers after adopting crossbred cattle but increase in female labour requirement is not found statistically significant (Table 5.11).

Table 5.11: Labour Use Effect of Crossbred Cattle Adoption According to Gender Groups (Person days/month)

Farm size	Gender	Labour use/farm		t-test
		Adopter	Non-adopter	
Small	Male	11.44 (0.833)	5.72 (0.571)	5.73*** (1.007)
	Female	7.33 (0.716)	4.13 (0.537)	3.20*** (0.893)
Medium	Male	15.65 (1.392)	8.186 (0.859)	7.46*** (1.714)
	Female	8.73 (0.850)	4.30 (0.457)	4.43*** (1.019)
Large	Male	31.13 (3.689)	14.66 (2.698)	16.47** (7.34)
	Female	10.06 (1.431)	6.88 (1.009)	3.18 (2.844)
Overall	Male	17.26 (1.194)	7.32 (0.538)	9.94*** (1.427)
	Female	8.43 (0.535)	4.39 (0.353)	4.03*** (0.679)

Source: Author's estimation based on field survey data

Notes: Figures in parentheses indicate standard error;

** and *** indicate significant at 5% and 1% probability level respectively

Figure 5.1 shows the distribution of labour use per dairy farm for adopter and non-adopter of crossbred cattle. It has been seen that the differences in the pattern of labour use between adopter and non-adopter is not much visible. But, as stated earlier, there are notable differences in the labour use activity-wise.

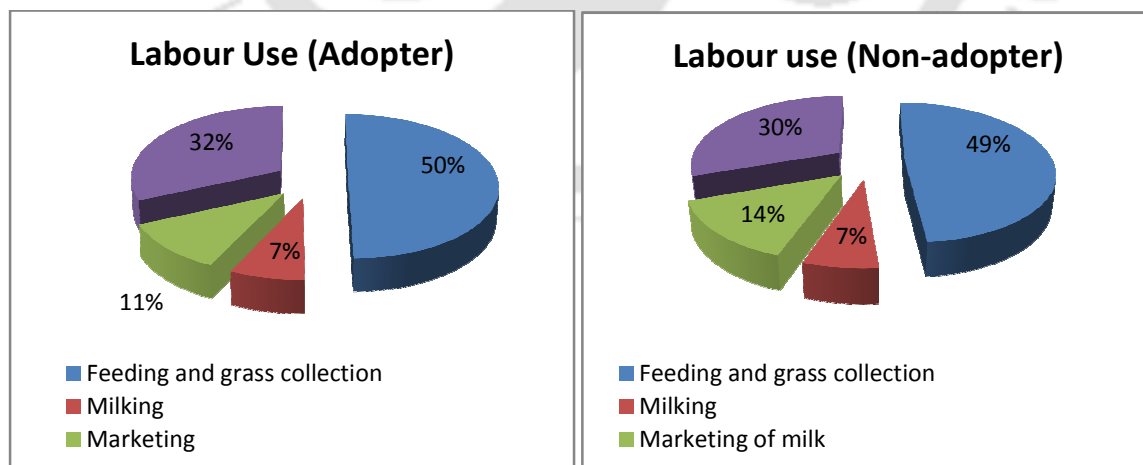


Figure 5.1: Operation-wise Distribution of Labour Use/farm for Adopter and Non-adopter
(Source: Table 5.10)

Regression Analysis

The estimation of employment effect is done using mean difference test of crossbred cattle adopters and non-adopters using *t*-test (two tailed) in Table 5.10 and Table 5.11. The robustness of the *t*-test results and relationship between milk production and monthly total labour use spent have been checked by employing the ordinary least squares (OLS) technique (log lin) to isolate the impact of crossbred cattle adoption on the total monthly labour use of the farmers. It is hypothesized that if there is higher employment effect of crossbred cattle adoption then the coefficient for the adoption dummy may be positive and significant with relatively higher magnitude. The relationship between the dependent and independent variable is explained by inclusion of some control variables which are hypothesized to have direct or indirect influence on the dependent variable. They are monthly household milk production, age of the household head, family size, distance to all-weather road, membership of dairy cooperative society, farm size, and distance to nearest village market. The following regression model is fitted in the study.

$$Y_i = \alpha + \gamma A_i + \sum_j^n \beta_j X_i + \mu_i \quad (5.3)$$

Where, Y_i refers to log of total person days spent per month by the i^{th} farmers; α is the intercept term; γ indicates the coefficient of crossbred cattle adoption dummy, A_i ; X_i refers to various farm and farmer characteristics influencing Y_i ; β_j are the partial regression coefficients where j varies from 1 to 7; μ_i is the standard error term.

In order to examine the effect of crossbred cattle adoption on employment, adoption dummy (1=adopter; 0= otherwise) of the farm household has been tested, controlling all other variables relating to farm and farmer characteristics. The sample means of the explanatory variables used in the regression are presented in Table 5.12. The variable household milk production is expected to have a positive relation with monthly labour use in the sample farms, because as production increases, there is higher requirement of time in care and management of the farm. Adopters are found to have a much higher production of

milk/month (141.30 litres) compared to the non-adopters (24.50 litres) due to the high yielding nature of crossbred cattle.

Farmer characteristics such as age of household head may be either positively or negatively related with labour use. The reason for positive relation is that older farmers are more experienced and have contacts with extension agents and may expand dairying by investing in high yielding cattle breeds or young farmers being innovative may commercially adopt high yielding crossbred cattle and thus invest more time in the care and management of the animal.

Table 5.12: Sample Mean of the Explanatory Variables Used in the OLS Regression

Variables	Unit of measurement	Adopter		Non-adopter	
		Mean	Std. error	Mean	Std. error
Milk production/month	Litres	141.30	14.939	24.50	1.887
Age of HH head	Years	50.67	1.101	49.78	1.167
Family Size	Numbers	5.72	0.203	6.14	0.257
Distance to All-weather road	Metres	350.00	33.283	471.77	35.902
Membership of Dairy Cooperative Society	Dummy (1=member; 0=otherwise)	0.46	0.043	0.11	0.030
Farm Size	Number	7.16	0.736	5.39	0.357
Distance to nearest Village Market	Km	2.85	0.137	3.15	0.161

Family size indicates availability of family labour. It is hypothesized to have a positive relation with the employment because as family size increases more number of persons within family offer services to the farm or in an increasingly labour scarce (of hired labour) farming system supply of labour is eased. In the sample farms average family is found to be relatively larger in the non-adopter farm (6.14) than the adopter farms (5.72).

Farm characteristics such as distance to all weather road and distance to nearest village market is expected to have a positive relation with the requirement of labour. As distance increases carrying of inputs (purchased feed and fodder) and selling of outputs (milk) takes more time leading to rise in the labour requirement. Table 5.12 shows that non-adopters are constrained in terms of these two farm characteristics.

Membership of dairy cooperative society (DCS) is a categorical variable. It is considered that being member of DCS will facilitate information access on key aspects of dairying

through discussion among farmers and may help in the adoption of commercial dairying through rearing of improved cattle breed. In the process, it results in increased use of monthly person days in the farm. Thus, there is positive expected relation between membership of cooperative society and labour hour spent.

It is expected that farm size is positively related with labour use. Labour requirement will increase if care and management are to be taken for larger number of animals. The average farm size is bigger for adopters of crossbred cattle (7.16) than the non-adopter households (5.39)

Table 5.13 presents the OLS (log linear) regression results of the factors affecting labour use in the sample dairy farms. The OLS regression is run using the software STATA 14. It is seen from Table 5.13 that significant F value and R^2 value (56.40%) indicate good fit of the model. All the explanatory variables conform to the expected sign in the model. It further shows that the target variable, adoption of crossbred cattle is found to be statistically significant at 1% probability level. It is seen that farm household with crossbred cattle have 24.77 per cent higher monthly labour use in the sample farms. This implies that crossbred cattle adoption has a much higher effect on employment generation. Efforts for diffusion of artificial insemination technology or deployment of purebred exotic bull will be instrumental in absorbing rural youths productively in the dairy sector. Other control variables, such as milk production/month, farm size and distance to nearest village market significantly affect labour use. It is seen that 1 litre increase in monthly milk production leads to 0.07 per cent increase in the overall labour absorption. Similarly, one unit increase in cattle numbers and one kilometre increase in the distance to nearest village market significantly leads to 0.73 and 3.42 per cent increase in labour use in the sample dairy farms. Our results are checked for presence of multicollinearity. The problem of multicollinearity is checked by using Variance Inflation Factor (VIF) and Tolerance Level (TOL) for the explanatory variables. The estimated VIF suggests that there is absence of multicollinearity problem (the mean VIF is 1.23) (see Table 5.14).

**Table 5.13: Factors Affecting Labour Use in Total Person Days/month in Dairy Farms:
OLS**

Variables	Coefficient	Std. Error	t-value
Adoption of Crossbred Cattle (1=Adoption; 0=otherwise)	0.2477***	0.0283	8.75
Milk production/month	0.0007***	0.0001	6.33
Age of HH head	-0.0005	0.0009	-0.55
Family Size	0.0027	0.0049	0.55
Distance to All-weather road	0.00004	0.00003	1.25
Membership of Dairy Cooperative Society	0.0115	0.0301	0.38
Farm Size	0.0073***	0.0020	3.56
Distance to nearest Village Market	0.0342***	0.0076	4.51
Constant	0.8401***	0.0625	13.43
Number of Observations		245	
F(8, 236)		38.15	
Prob>F		0.000	
R-squared		0.5640	

Source: Author's estimation based on field survey data

Note: Significant * at 10%, ** at 5% and *** at 1% probability level

The discussion in the foregoing section reveals that adoption of high yielding crossbred cattle results in higher labour requirement which may partially help in solving unemployment problem in the state of Assam. If it becomes possible to achieve national average of 20.81 per cent of crossbred cattle population by effectively implementing the crossbreeding programme in the state of Assam then it may create 158400.53 and 192102.77 person days/month for small and medium farms respectively⁴. In a situation when agriculture sector is grappled with the problem of disguised unemployment coupled with stable or declining labour use in the crop sector, alternative farming system such as commercial dairying with crossbred cattle may lead to a win-win situation (productivity growth plus labour absorption). Thus given that the proportion of crossbred cattle is abysmally low in the state (3.84 per cent) compared to the national average, it is suggested to take policy priority towards laying more emphasis on the crossbreeding programme in the state. Controlling selection bias of farmers being in the adopter group, labour use effect of crossbred cattle adoption is further shown in the next chapter (Chapter six) using propensity score matching technique.

Table 5.14. Variance Inflation Factor (VIF) of the Explanatory Variables: OLS

Variable	VIF	Tolerance
Milk production/month	1.66	0.60
Age of HH head	1.04	0.96
Family Size	1.04	0.96
Distance to All-weather road	1.07	0.94
Membership of Dairy Cooperative Society	1.30	0.77
Farm Size	1.66	0.73
Distance to nearest Village Market	1.03	0.97

5.5. Milk Marketing, Market Accessibility and Determinants of Marketed Surplus

5.5.1. Marketing of milk

Milk production, sales and retention for self-consumption on the sample households for the two different adoption groups are presented in Table 5.15. The table shows that average milk production, sales and retention for self-consumption are directly related to farm size. This indicates that production, sales and household retention for self-consumption increases with the increase in farm size for both the adoption groups. It is seen from Table 5.15 that production, sales and retention for consumption of milk per farm across farm size groups among adopters are 15.14, 13.43 and 1.72 (11.36 per cent) litres respectively. Production of milk per farm for crossbred cattle adopter group stands at 8.01 litres for small farms (<3 milch SAU) that increases to 11.99 and 34.07 litres per farm for medium (3<6 milch SAU) and large (≥ 6 milch SAU) farms respectively. Similar pattern of sales and retention for self-consumption is envisaged among the adopter group of the sample farmers. Again, among the non-adopter farmers overall production of milk per farm is found to be 3.12 litres of which 2.19 liters per farm is sold by the farm household and the remaining 0.93 litres (29.81 per cent) retained for consumption in liquid form and/or consumed as processed product. The retention for self-consumption for small farms (<3 milch SAU) of the non-adopter category farm households is as high as 37.83 per cent of the per farm milk production. The reason for such high consumption proportion of this group is that a sizeable number of sample farmers in the non-adopter group are autarkic farmers who produce milk solely for self-consumption (see Table 5.16). It is, thus, seen that almost 30% of the farm milk production for sample farmers across groups of the non-adopter category is consumed domestically and the rest

70% is sold as marketed surplus. Thus, Table 5.15 explains that adopters have higher absolute consumption and sales of milk per farm commensurate with increased production in relation to the sales and consumption of non-adopters. This finding corresponds to the finding of Kumar and Shah (2016) where it is said that consumption of milk is proportional to with the volume of milk production and there exists also a clear difference in milk consumption level between producer and non-producer households.

Table 5.15: Milk Production, Sales and Retention for Consumption Pattern among Sample Household (Litres/day)

Farm size	Adopter				Non-Adopter			
	Production	Sales	Retained for consumption	% consumption	Production	Sales	Retained for consumption	% consumption
Small	8.01	6.69	1.32	16.48	2.30	1.42	0.87	37.83
Medium	11.99	10.14	1.85	15.43	3.32	2.34	0.97	29.22
Large	34.07	31.82	2.25	6.60	8.19	7.13	1.06	12.94
Overall	15.14	13.43	1.72	11.36	3.12	2.19	0.93	29.81

Source: Field survey, 2015-16

Table 5.16 presents the market participation behavior of the crossbred adopter (or non-adopter) farm households. Farm household that produce milk solely for their domestic consumption apparently do not generate marketed surplus. In contrast, rest of the farm households, apart from part of their produced milk consumed domestically, also produces a major proportion for market. Table 5.16 reveals that higher level of market participation is more explicit for crossbred adopters compared to non-adopters. In other words, adopters are commercially oriented to a higher extent in their milk production behavior. Of the 137 sample farmers with adoption of crossbred cattle, 98.54 per cent farmers are market participant that sells a part of their produce in market (or any other marketing agent) against

Table 5.16: No. of Sample Farmers According to Market Participation Status

Farm category	Participant	Non-participant	Total no. of sample farmers
Adopter	135 (98.54)	2 (1.46)	137 (100)
Non-adopter	90 (83.33)	18 (16.67)	108 (100)
Total	225 (91.84)	20 (8.16)	245 (100)

Source: Field survey, 2015-16

the 83.33 per cent of the non-adopters. However, producing for the market must be incentivized by availability of effective marketing options for the farmers. The next section presents the various marketing options farmers utilizes to sell their marketed surplus and their respective average prices of milk.

5.5.2. Access to market

The marketing of milk and milk products in Assam is on a small scale, partly because of the demand-side constraints and partly because of lack of effective marketing strategy to overcome the demand-side constraints (Sirohi et al., 2009). An effective marketing condition particularly for agricultural commodities can facilitate agricultural intensification resulting from higher accrual of farm profit. According to Sharma (2016), smallholder farmers face various marketing constraints that either raise marketing costs or market risks associated with market access and market information. In Assam, the large scale informal milk handling in the marketing side exposes the dairy farmers to the clutches of middleman that slashes the remunerative price significantly. It is evident from Table 5.17 that more than one third of total produce (37.11 per cent) across farm size groups are bought by cooperatives followed by market pulling almost one fourth of the total produce (25.69 per cent). In the existing marketing channels on the sample households, private traders may be considered exploiter of the small and marginal farmers due to the lowest price of milk offered, i.e., Rs. 28.31. The prevalence of dairy cooperative society (DCS) assists the dairy farmers by regularly procuring milk from the member-producers even during a sudden declaration of *bandh* (strikes) and extending non-market support such as providing help during the time of credit needs of the farmers, supplying quality concentrate and extension support. It is also observed during the primary survey that certain milk producers have fixed buyers in the neighborhood that picks up milk from the farmer's doorstep during the period when farmers are producing surplus milk. The price claimed by the sample farmers for retail selling is usually at par with the market price of milk. Table 5.17 shows that almost 13 per cent of the total milk produced is sold retail in the neighborhood of the farmers. According to size classes of farmers, large farmers use private trader relatively more compared to small and medium farmers as the source of milk sale (28.03). This is for the reasons that these farmers being handicapped with manpower shortage and due to voluminous production

resorts to private trader to collect the milk from the farmer's doorstep. However, a large part of the milk is also sold in the market by this group of farmers (41.08 per cent) to fetch better prices. Table 5.17 further shows that small and medium farmers are the highest user of DCS to source the milk sale because of the advantages discussed above and prices fetched by the farmers which are relatively better than the price offered by private trader (Rs. 33.48/litre against Rs 28.31/litre). Thus, among the marketing channels prevalent on the overall sample farmers, cooperative and farmers selling self to the market together constitute as the dominant source of milk sale (almost 63 per cent) followed by the rest of the sources, that is, selling to private traders and retail sale in the neighborhood.

Table 5.17: Sale Pattern by Type of Buyers among Selected Households that are Net Sellers of Milk

Farm size	Private trader		Market		Cooperative		Sold retail in the neighborhood	
	Per cent	Price (Rs/litre)	Per cent	Price (Rs/litre)	Per cent	Price (Rs/litre)	Per cent	Price (Rs/litre)
Small	10.10	30.58	37.18	40.00	40.89	34.04	10.91	38.44
Medium	14.17	26.50	15.52	39.65	46.65	33.57	23.32	39.00
Large	28.03	27.83	41.08	38.92	14.01	28.50	16.88	40.00
Overall	14.93	28.31	25.69	39.68	37.11	33.48	13.04	39.14

Source: Field survey, 2015-16

5.5.3. Determinants of marketed surplus of milk

Studies indicate that marketed surplus of agricultural output depends on various price and non-price factors (Sharma, 2016). Empirical studies show that farmers respond positively towards price change and the finding is consistent with economic theory. However, there are other non price variables relating to socio-economic, institutional, technological and infrastructural factors that affect marketed surplus. In most cases, there remains a strong linear and in certain cases non-linear relationship between the quantity sold out and factors such as farm size, volume of production, household size, prices of output received and socio-economic and institutional factor such as access to credit, distance to market etc. Thus, the postulated linear relationship between the dependent and explanatory factors designed for the present study can be written as:

$$Y_i = \alpha + \beta_i X_i + \mu \quad (5.4)$$

Where, Y_i represents the marketed surplus as a percentage of total output per household, and X_i ($i = 1, 2, \dots, n$) represents the explanatory factors affecting marketed surplus. Marketed surplus is defined as sales as a percentage share of total output per household. Independent variables include adoption of crossbred cattle (dummy: 1=adopter; 0 otherwise), herd size (number of milch SAU), family size (numbers), price received for the milk sold (Rs/litre), distance to nearest market (kilometre), membership of DCS (dummy: 1=member; 0 otherwise) and access to credit (dummy: 1=accessed; 0 otherwise). It is hypothesized that with the increase in adoption of crossbred cattle, herd size, family size, price received for the milk sold, membership of DCS and access to credit, the marketed surplus should increase. On the other hand, distance to market is expected to have a negative effect on the marketed surplus of milk. It is also hypothesized that since crossbred adopters are relatively more commercially oriented compared to non-adopters (from the analysis of Table 5.16), crossbred cattle adoption variable should have highly significant relationship with the dependent variable and also have higher β coefficient.

The result of the multiple linear regression analysis to examine the impact of various market and non-market factors influencing marketed surplus of milk is presented in Table 5.18. It shows that the marketed surplus model has a significant F value of 42.41 (p -value = 0.000) and a high R^2 value of 0.5561 which indicate a better fit of the model. The independent variables are free from the problem of multicollinearity as the mean VIF value is less than 5 (See Table 5.19). Perusal of Table 5.18 shows that except family size and distance to market, the changes in the remaining variables bear positive relationship with changes in marketed surplus. The existence of an inverse and significant (p -value < 0.10) relationship between distance to market and marketed surplus explains that higher the distance to market, lower is the marketed surplus of milk. The possible explanation for the inverse relationship can be that use of other marketing channels (such as private trader, cooperatives and retail selling in the farmer's neighborhood) has stronger effect than selling directly in the market. As, it is evident from Table 5.17 that more than 65 per cent of the total produce is sold to cooperatives or picked up by professional vendor and buyers in the neighborhood. The negative relation between family size and marketed surplus of milk shows that higher the size of the family lower is the marketed surplus. One strong hypothesis behind postulating the model was that adoption of crossbred cattle has stronger and highly significant effect on

increased marketed surplus due to adopter's milk production activity strongly guided by market participation. The result of the same is found as expected as it is found from Table 5.18 that crossbred cattle adoption is highly significant (p value = 0.000) and likely to induce a 14.60 per cent higher marketed surplus. Other explanatory variables such as herd size, price received for the milk sold and membership of DCS are positive and highly significant to influence increased marketed surplus. Price received on the sale of milk is an important signal in the study location to positively influence marketed surplus of milk. The elasticity of marketed surplus of milk to its price change is about 1.33, implying that increase in the price of milk fetched by one rupee likely to induce a 1.33 per cent higher marketed surplus. Similarly, one cattle head increase in the herd size and rise in the probability of becoming member of DCS respectively results in 0.58 and 4.34 per cent increase in the marketed surplus of milk. Family size matters and it has negative but statistically non-significant influence on marketed surplus of milk in the present study.

Table 5.18: Factors influencing marketed surplus of milk

Factors	β - value	"t" Value	Relative rank
Constant	14.2908*** (5.3463)	2.67	-
Crossbred cattle adoption	14.6031*** (2.5046)	5.83	2
Herd size	0.5798*** (0.1736)	3.34	3
Family size	-0.6879 (0.4407)	-1.56	6
Price received for the milk sold	1.3339*** (0.1068)	12.49	1
Distance to market	1.3448* (0.6839)	1.97	4
Membership of DCS	4.7210** (2.6357)	1.79	5
Access to credit	2.4576 (3.0316)	0.81	7
F value		42.41***	
R ²		0.5561	
No. of observation		245	

Source: Author's estimation based on field survey data

Notes: Figures in parentheses indicate standard error;

*, ** and *** indicate significant at 10%, 5% and 1% probability level respectively

The relative importance of factors influencing marketed surplus as measured by standardized regression coefficient implies that price fetched for the milk sold is the most important factor, followed by crossbred cattle adoption, herd size, distance to market, membership of DCS and family size. Access to credit is the least important factor to affect marketed surplus of milk. The findings are in similar line with the findings of some of the empirical studies such as Sharma (2016) carried out for the marketed surplus of rice and wheat in some of the major agricultural states in India.

Table 5.19: Variance Inflation Factors (VIF) of the Explanatory Variables

Variables	Collinearity Statistics	
	VIF	Tolerance
Crossbred cattle adoption	1.29	0.77
Herd size	1.23	0.81
Family size	1.10	0.90
Price received for the milk sold	1.07	0.93
Distance to market	1.06	0.94
Membership of DCS	1.04	0.96
Access to credit	1.04	0.96
Mean VIF	1.12	

5.6 Summing Up

The surveyed households in the present chapter are categorized into small, medium and large farms by using cumulative frequency of the square root technique. The milk productivity of cattle and various underlying issues of milk production are analyzed according to disaggregation of farms. Chapter five presents that there is significant difference in milk productivity between crossbred and indigenous cattle. This point out that crossbred cattle yields approximately 537 litres of more milk per lactation compared to indigenous cattle. In terms of various lactation and reproductive characteristics of crossbred and indigenous cattle it is indicated that crossbred cattle are highly superior over indigenous cattle in terms of age at first calving, calving interval and lactation length. The chapter also indicates that concentrate is the most important input to significantly affect productivity of crossbred and indigenous cattle followed by feeding of dry fodder. Using imputed value of domestically available inputs including labour and imputed value of domestically consumed milk, returns from milk production is estimated. This is again compared with the returns

from milk production based on actual paid out cost and income received from milk sold in the market. It is found that for the average size of cattle holding of adopters of crossbred cattle (5.69 milch SAU), the annual income based on cost and returns would be Rs. 76,884.99 against the income of non-adopters (2.65 milch SAU) of Rs. 2534.20. With actual paid-out costs and returns from milk sale, the annual income for the average size of cattle holding is estimated at Rs. 1,27,933.96 for adopters and Rs. 18,590.55 for non-adopters. Higher net returns based on actual paid-out costs and returns from milk sold implies that internal flow of input in a mixed farm system and operating dairy business using mostly family labour incentivize farmers to go for dairying using improved breeds due to higher net returns. The study also makes attempt to identify factors influencing profitability in dairying in the chapter based on the two sets of models. Identification of factors determining profitability of milk production is guided by inclusion (or exclusion) of cost and return imputations which brings differing direction and significance level of independent variables affecting the dependent variable in model 1 and model 2. Various dairy farming operations engage human labour. It is found in chapter five that as farm size increases, irrespective of breed of cattle, the engagement of male labourers is proportionately more than the female labourers. It is also seen based on t-tests that crossbreeding technology adoption is associated with increased amount of labour use for various farming operations per farm and per standard animal unit, and there lies a clear heterogeneity in the level of labour use according to farm size and farm operations. Further, the chapter points out that adopters have higher absolute consumption and marketed surplus of milk per dairy farm commensurate with increased production compared to the consumption and marketed surplus of non-adopters. Again, adopters are commercially oriented in their milk production behavior as 98.54 per cent of the adopter farmers produce milk for market against the non-adopters of whom almost 17 per cent of the farmers produce milk for self-consumption. The chapter has also highlighted the available sources of milk sale for the sample farmers that generate marketed surplus and their prevailing prices of milk for each source. It is seen that percentage distribution of marketed surplus by type of buyers varies with the variations in size-classes of farmers. However, for the overall sample farmers, cooperative and farmers selling self to the market together constitute as the dominant source of milk sale (almost 63 per cent) followed by the remaining sources. The chapter finally focused on identification of

market and non-market factors determining the marketed surplus of milk. It shows that crossbred cattle adoption significantly affects 14.60 per cent higher marketed surplus. Other factors such as herd size, price received for the milk sold and membership of DCS are positive and highly significant to influence marketed surplus.

Notes:

1. For standardizing the herd size among the sample farmers following standards were followed:

a) Milch crossbred = 1.40

b) Milch Indigenous =1.00

2. Rao et al. (1995) point out that the average age of first calving for crossbreds ranges from 25 to 33 months compared to 38 to 41 months for indigenous cattle.

3. The percentage share showed opposite direction because with the inclusion of the imputed value of family labour the total imputed operational cost jumped significantly and this reduced the percentage share of dry fodder in the total imputed operational costs.

4. According to Livestock Census, 2012, the total milch cattle is calculated to be 3072772 numbers and assuming that there is 20.81 per cent crossbred milch cattle in the state, the total milch cattle becomes 639443.85 numbers. Accordingly number of monthly person days for small or medium farms (from Table 5.10) is extrapolated.



CHAPTER SIX

CROSSBRED CATTLE ADOPTION AND TREATMENT IMPACT ON FARMERS' WELLBEING

Chapter five brings forth some important milk production and productivity characteristics of crossbred cattle adopters and non-adopters for the sample farm households surveyed in three districts of Assam. Analyses on economics of milk production and farm level employment in the two production systems (with and without crossbreds) and marketed surplus and marketing of milk provides interesting findings in the previous chapter. Chapter five also points out various productivity and other reproductive and lactation characteristics between the two breeds of cattle owned by the sample households. It is noted that crossbred cattle are found to be superior over indigenous breeds. Regarding economics of milk production among the sample farmers, the net returns under both imputed (for domestically supplied inputs including labour) and actual costs computations are found to be significantly higher for crossbred cattle adopters compared to the non-adopter counterpart. It is also noted while identifying the determinants of farm profitability with and without imputations of various farm inputs including labour show differing directions and significance level of the explanatory factors. Furthermore, it shows based on *t*-test (two tailed) and multiple regression technique that crossbred cattle adoption is associated with increased amount of labour use. Chapter five also highlights the important determinants of marketed surplus of milk among the sample households using OLS technique. Interestingly, it shows that crossbred cattle adoption significantly affects 14.60 per cent higher marketed surplus.

The present chapter attempts to study the impact of crossbred cattle adoption on major outcome variables relating to household wellbeing such as household income from various sources, labour use to understand employability prospect of crossbreeding programme and consumption of high value commodities for nutritional requirements of farm households. Two components of outcome indicators of farm households, viz. net dairy income and labour use are estimated in chapter five to see the difference between adopters and non-adopters of crossbred cattle using *t*-test. However, the estimation process may have endogeneity problem due to farmers' self-selection of being into the adopters' group. Thus, impact estimates using suitable micro-econometric techniques may address selection bias and may give robust estimation of the outcome indicators mentioned above. The primary objective behind the work in the current chapter is to understand the superiority of new

technology such as high yielding crossbred cattle in order to justify the need for policy priority towards diffusion of breeding technology, i.e., AI.

The rest of the chapter is organized in six sections. Section 6.1 discusses the conceptual framework of improved technology adoption such as crossbred cattle and the estimation technique. Section 6.2 elaborates on the variable choice and estimation of propensity scores. In section 6.3, estimation of average treatment effects on the treated (ATT) is done for the outcome variables of our concern in order to find the treatment impact of crossbred cattle adoption. While, section 6.4 tries to enquire if there is treatment heterogeneity according to certain important farm characteristics, section 6.5 checks robustness of the ATT by using alternative propensity score specifications. Section 6.6 finally sums up the whole discussion of the chapter.

6.1. Conceptual Framework and Estimation Technique

6.1.1. Conceptual Framework: Technology Adoption and Household Wellbeing

Following Becerril and Abdulai (2010), Gitonga et al. (2013) and Khonje et al. (2014), the adoption decision of a new technology such as high milk yielding crossbred cattle is modeled in a random utility framework. A dairy farmer may adopt new technology only in the situation when the expected utility derived after adoption of the technology is more compared to the traditional technology. Considering that the farmer is risk neutral the index function for estimating adoption decision of improved cattle breed can be expressed as:

$$Z_i^* = T_i' \gamma + \varepsilon_i \quad (6.1)$$

Where Z_i^* is a latent variable indicating the difference between the utility derived from adopting improved cattle breed (U_{iA}) and from non-adoption of improved cattle breed (crossbred cattle) denoted by U_{iN} . Farmers i will go for new technology if $Z_i^* = U_{iA} - U_{iN} > 0$. However, the utilities derived from adoption and non-adoption is unobservable. In this case what can be done is to postulate a relationship between unobservable and observable variables. The term $T_i' \gamma$ provides an estimate of the difference in utility from adopting improved cattle breeds ($U_{iA} - U_{iN}$), using the observable farm and farmer characteristics. γ is a vector of parameters to be estimated and ε_i is an error term.

The basic relationship we consider between adoption of new technology and changes in the household wellbeing measured in the study in terms of income, consumption of protein-rich high

value food and employment, is a linear function of a vector of explanatory variable (X_i) and a technology adoption binary variable (D_i). The linear regression equation can be specified as

$$Y_i = \alpha X_i + \beta D_i + \mu_i \quad (6.2)$$

Where Y_i denotes the outcome variables of our interests, μ_i is the standard normal disturbance term and D_i is an indicator variable for technology adoption; $D_i = 1$ if technology is adopted and $D_i = 0$ otherwise. X_i indicates vector of explanatory variables representing farm and farmer characteristics. Becerril and Abdulai (2010) and Gitonga et al. (2013) observe that due to the inherent differences with respect to observable and unobservable characteristics of both adopters and non-adopters it becomes a non trivial issue to compare outcome variables between the adopters and non-adopters. In estimating equation 6.1 and 6.2, one needs to take note that the relationship between adoption of new technology and outcome variable of our interest could be interdependent. Here, thus appears the problem of self selection into treatment with group of adopters being systematically different from non-adopters. According to Gitonga et al. (2013), a simple regression model containing binary adoption variable as treatment variable, fails to control for selection bias emanating from differences in observed and unobserved characteristics.

Various methods have been proposed by researchers in literature available to address selection bias. de Janvry et al. (2011) have proposed random assignment to treatment as one way to reduce selection bias but for ex-post studies like ours it is impossible to follow this method. Some authors are found to employ Heckman two-step method to deal with selection bias in situations when correlations between the two error terms are greater than zero. The major limitation of this approach is its reliance on the restrictive assumption of normally distributed error terms (Becerril and Abdulai, 2010). One way of controlling selection bias is to employ instrumental variable (IV) approach (Abadie, 2003; Angrist, 2004; Yen et al., 2008; Heckman and Navarro-Lozano, 2004). However, a major drawback of this approach is its challenge to find or in identifying correct instruments in the estimation process (Imbens and Woolridge, 2009). Additionally, the IV approach violates the overlap assumption by not relying on exogeneity assumptions (Imbens, 2004) and IV approach like OLS imposes functional form assumption indicating that the coefficients on the control variables are similar for adopters and non-adopters (Jalan and Ravallion, 2003). This assumption may not hold because coefficients are different instead of being similar (Becerril and Abdulai, 2010). Other potential panel data method that can control unobservables is the difference-in-differences method (Heckman et al., 1997; Abadie, 2005), panel estimators with household fixed effects and first differences. But, since the present study is based on cross-sectional data and panel data is rarely

available in our case, these methods are inappropriate in the context of present study. Another econometric method that deals with the problem of selection bias using cross-sectional data in a non-experimental causal framework and ignoring functional or distributional form assumptions or exogeneity of covariates is the propensity score matching (PSM) method (Gitonga et al., 2013; Heckman et al., 1997; Jalan and Ravallion, 2001). This method has gained immense popularity in the recent studies dealing with impact evaluation of programme participation. In PSM technique selection bias is addressed by conditioning on observable variables and does so by matching each adopter households to its one or more non-adopting counterparts with similar observable characteristics. One limitation of PSM technique, however, is that it fails to capture selection bias based on unobserved heterogeneity which can partially be corrected by Rosenbaum bounds sensitivity analysis if PSM results are sensitive to hidden bias.

In several of the recent studies on impact evaluation of different agricultural technologies adoption are found to have been carried out using PSM technique in different parts of the world. These studies include impact of metal silos adoption on maize storage, storage losses and food security in Africa (Gitonga et al., 2013); impact of adoption of improved maize varieties on crop incomes, consumption expenditure and food security in Eastern Zambia (Khonje et al., 2015); adoption of genetically modified cotton and its impact on poverty in Pakistan (M'mboyi et al., 2010); Impact assessment of improved agricultural technologies such as improved maize seeds, improved granaries, tractor mechanization, and animal traction on household income in rural Mozambique (Cunguara and Darnhofer, 2011); Adoption of improved maize varieties on household income and poverty reduction in Mexico (Becerril and Abdulai, 2010); adoption of improved groundnut varieties and its impact on rural poverty in Uganda (Kassie et al., 2011). This method has also been used to evaluate the impact of maize-pigeonpea intensification in Tanzania (Amare et al., 2012); improved pigeonpea and chickpea varieties adoption in Ethiopia and Tanzania (Asfaw et al., 2012); impact of adoption of integrated rice-fish farming system on welfare of marginalized indigenous farm households in Bangladesh (Islam et al., 2015) and impact of agricultural technology adoption on poverty alleviation strategy in Rural Bangladesh (Mendola, 2007). To our knowledge, this method has not been applied so far to study the impact of crossbreeding technology adoption on wellbeing indicators of farmers such as income, consumption and employment.

6.1.2. Propensity Score Matching: Estimation Technique

Following Heckman et al. (1998), Amare et al. (2012), and Rosenbaum and Rubin (1983), each person may have two possible outcomes, Y_0 and Y_1 in the untreated (control) or treated

(experimental) states respectively. In a situation when each person has only Y_1 or Y_0 and never both, the issue of programme participation becomes a non-trivial issue. When there is the problem of self selection of programme participation, let Y_1 be the value of outcome indicators (income from various sources, labour use and per capita daily consumption of high value commodities) when the household i is subject to treatment, i.e., adopt high yielding crossbred cattle ($z = 1$) and Y_0 , the same variable when it does not adopt crossbred cattle ($z = 0$). The observed outcome becomes,

$$Y = zY_1 + (1 - z)Y_0 \quad (6.3)$$

When, ($z = 1$) we observe Y_1 and when ($z = 0$) we observe Y_0 . The average effect of treatment on the treated (ATT) is defined as

$$ATT = E(Y_1 - Y_0 | z = 1) = E(Y_1 | z = 1) - E(Y_0 | z = 1) \quad (6.4)$$

However, it is not possible to get a gross impact $Y = Y_1 - Y_0$ for the same person. In other words, we can only observe the outcome variable i.e., income, consumption and labour use of adopters $E(Y_1 | z = 1)$ and unable to observe the outcome variables for those adopters had they not adopted $E(Y_0 | z = 1)$. Therefore, matching estimation assumes counterfactual analysis by matching the control with the treatment observations. The primary assumption in the matching process is the conditional independence assumption (CIA) which states that given a set of observable covariates X which are unaffected by treatment, potential outcomes are independent of treatment assignment (Caliendo and Kopeinig, 2005). According to Mendola (2007), CIA is more plausible than in case of OLS, since it is assumed that technology adoption is random (not correlated with X) within groups of households that have identical behavior towards adoption of Technology. In notation,

$$(Y_1, Y_0) \perp z | X, \quad \forall X \quad (6.5)$$

This implies that the counterfactual outcome (income from various sources, labour use and per capita daily consumption of high value commodities) indicators in the treated group are the same as the observed outcome for the nontreated group

$$ATT = E(Y_0 | X, z = 1) = E(Y_0 | X, z = 0) = E(Y_0 | X) \quad (6.6)$$

Now, when we are based upon CIA, it rules out adoption on the basis of unobservable gains from adoption. The CIA also requires, apart from solely based on observable characteristics,

that the set of X 's should contain all the variables that influence treatment assignment and potential outcomes simultaneously (Amare et al., 2012; Caliendo and Kopeinig, 2005).

Thus, under CIA, computation of ATT becomes as follows,

$$ATT = E(Y_1 - Y_0 | X, T = 1) = E(Y_1 | X, T = 1) - E(Y_0 | X, T = 1) \quad (6.7)$$

Where, Y_1 and Y_0 is the treated and untreated outcome respectively, and T indicates treatment assignment and is equal to 1 if the household receives treatment and 0 otherwise. When the set of covariates is sufficiently large, matching the two adoption groups based on observed covariates may not be desirable or difficult due to dimensionality. Rosenbaum and Rubin (1983) suggested that in order to deal with the problem of dimensionality, the use of balancing score as a single index variable is important which summarizes the observed covariates. Propensity score as a single index variable $P(X)$ indicates the conditional probability for an individual to participate in a treatment which is one such balancing score that can be written as-

$$P(X) = \Pr(z = 1 | X) \quad (6.8)$$

The ATT in equation (6.4) can then be written as

$$ATT = E(Y_1 | P(X), z = 1) - E(Y_0 | P(X), z = 1) \quad (6.9)$$

A further requirement besides CIA is the common support or overlap condition while matching treated and untreated groups. It rules out the phenomenon of perfect predictability of z given X :

$$0 < P(z = 1 | X) < 1 \quad (6.10)$$

This indicates that household with the same values of covariates have a positive probability of being either participants or not-participants (Heckman et al., 1999).

Literatures on propensity score matching suggest practice to check whether the distribution of relevant covariates is balanced in both (treatment and comparison) groups. (Rosenbaum and Rubin, 1985; Lee, 2008; Caliendo and Kopeinig, 2008). Prior studies have indicated a number of tests to reduce the influence of confounding variables (Rosenbaum and Rubin, 1985; Sianesi, 2004; Caliendo and Kopeinig, 2005). The present study thus adopts tests such as the equality of means of the relevant covariates in the treatment and comparison groups after matching by using two sample t -tests implying that after matching there should not be any significant differences. Another test through which the matching quality is assessed is

by comparing the pseudo R^2 and p -values of likelihood ratio test of the joint significance of all the covariates obtained from Probit analysis before and after matching the samples. The rule of thumb is that pseudo R^2 after matching should be sufficiently lower and the joint significance of covariates should be rejected (or p -values of the likelihood ratio should be insignificant) (Sianesi, 2004). Several of the empirical studies using propensity score matching used propensity score graph to visually check if the common support condition is satisfied or there is substantial overlap in propensity score.

Additionally, Rosenbaum and Rubin (1985) suggest the use of mean absolute standardized bias (MASB) between adopters and non-adopters where it is recommended that standardized difference of greater than 20 per cent should be considered as too high and becomes an indicator that matching process has failed to satisfy the balancing property. In case of MASB, for each observable and propensity score, the standardized bias is estimated before and after matching as:

$$SB(X) = 100 X \frac{\bar{X}_t - \bar{X}_{nt}}{\sqrt{\frac{V_t(X) + V_{nt}(X)}{2}}} \quad (6.11)$$

Where \bar{X}_t and \bar{X}_{nt} are the sample means for the treatment and non-treatment (comparison) groups respectively. $V_t(X)$ and $V_{nt}(X)$ are the corresponding sample variance (Caliendo and Kopeinig, 2008). The bias reduction (BR) can be computed as:

$$BR = 100 \left(1 - \frac{B(X)_{after}}{B(X)_{before}} \right) \quad (6.12)$$

Prior studies on propensity score matching are found to use a number of methods to match the similar pair of adopters and non-adopters. The most commonly used matching methods are nearest neighbor matching (NNM), kernel-based matching (KBM) and radius matching (RM). It is also found that within the same variant of matching method, different bandwidth/caliper are used. The nearest neighbor matching method consists of each treated individual with the control individual that has the closest propensity score (Becerril and Abdulai, 2010). More commonly NNM is used with replacement in the control observations.¹ In the next step of propensity score matching using NNM is to estimate the differences of each pair of matched observations and the resulting mean difference is

obtained as ATT. KBM is a non-parametric matching estimator that used weighted averages of all comparison units to construct the counterfactual outcome. KBM method has one major advantage that it has lower variance which is possible because of more information being used. In radius matching, it is indicated that unit that lies within the radius (propensity range) and is closest in terms of propensity score. The basic idea of radius matching is to use not only the nearest neighbour within each caliper but all the comparison members within the caliper (Caliendo and Kopeinig, 2005)

6.2. Variable Choice and Estimation of Propensity Score

6.2.1. Descriptive Statistics

In estimating the impact of crossbred cattle adoption on wellbeing of the sample farmers, the study has considered outcome indicators such as household income, consumption of protein rich high value commodities and employment. Household income is estimated according to different sources that include dairy income, income from livestock (other than dairying), crop and/or plantation income and off-farm income. Similarly, consumption of high value commodities incorporates consumption of milk, fish, meat, fruits and vegetables. Employment effect of crossbred cattle adoption is measured as changes in the total person days per month engaged in dairying after adoption and further disaggregating the changes in total person days into male and female person days per month. Table 6.1 to Table 6.3 presents the outcome variables and their descriptive statistics. For the purpose of the study adopters are classified as farmers who are found to have at least one high yielding in-milk crossbred cattle during the survey and non-adopters are referred to the farmers who are found rearing only local (*desi*) cattle breed. Table 6.1 reports that *ceteris paribus* the mean difference test between adopters (treatment group) and non-adopters (comparison group) of crossbred cattle is significant for the important outcome variables such as net dairy income, livestock income, total household income and net dairy income per milch cattle per day. It is seen from Table 6.1 that holding other things constant adopters have significantly ($p=0.000$) higher dairy income equivalent to Rs. 73,581.99 per annum compared to the non-adopter counterpart.² Similarly, the annual livestock income and household income of adopters over non-adopters are significantly higher by Rs 3940.81 and Rs. 93205.67 respectively. The two important components of total household income such as crop income and off-farm income

show positive rise for adopters compared to its non-adopter counterpart but the increase is statistically insignificant. In order to normalise the net dairy income differences between adopter and non-adopters in terms of herd size net dairy income per milch cattle per day is computed for the sample data set. It is seen from Table 6.1 that *ceteris paribus* adopters have statistically significant ($p=0.000$) higher income of Rs 51.61 per milch cattle per day against the non-adopter counterpart.

Table 6.1: Mean Income from Different Sources during 12 Months Preceding the Survey for the Sample Farmers and their Mean Difference Test

Outcome Variable	Treatment (N=137)		Comparisons (N=108)		t-test (2-tailed)	
	Mean	Std. error	Mean	Std. error	Difference	p-value
a) Value of Milk Produced (Dairy Income) (Rs)	158566.60	19328.980	26548.470	1951.726	132018.10	0.000
Value of milk sold (Rs)	141032.60	19027.390	18500.280	1912.757	122532.30	0.000
Value of milk consumed (Rs)	17534.010	984.902	8048.194	443.855	9485.820	0.000
b) Paid out Expenses of Milk Production (Rs)	69979.790	9142.695	11543.650	1014.237	58436.140	0.000
c) Net Dairy Income (a – b)	88586.820	11103.550	15004.820	1183.291	73581.990	0.000
d) Income from Livestock (Excluding Dairy) (Rs)*	9120.438	960.227	5179.630	568.071	3940.808	0.001
e) Net Crop Income (Rs)#	27253.280	5714.343	21061.110	8404.365	6192.174	0.530
f) Off Farm income (Rs)@	102949.50	12435.610	93458.80	10823.240	9490.693	0.577
g) Total household income (Rs) (c+d+e+f)	227910.40	17384.69	134704.40	13493.33	93205.670	0.000
f) Net Dairy Income/milch Cattle/Day (Rs)	70.63	4.95	19.03	1.42	51.61	0.000

Source: Author's estimation based on field survey data;

Notes: $p < 0.01$, $p < 0.05$ and $p < 0.1$ indicates significant at 1%, 5% and 10% respectively; * Includes the income from selling of live animals such as cattle, buffalo, poultry, and other output mainly egg, cow dung etc. # Net Crop Income refers to the value of crop output minus the intermediate cost. @ Off farm income refers to income accrued to the household from all the sources other than net income received from dairying, livestock and crop production

The other outcome variables of our choice are the per capita daily consumption of protein rich and high value food commodities and employment (labour use in person days per month). Table 6.2 presents the mean difference test of per capita daily consumption of milk, fish, meat, vegetables and fruits between the members of adopter and non-adopter households of crossbred cattle. It is found that other things remaining constant, there is statistically significant increase in per capita consumption of milk, fish, meat and fruits after adoption of crossbred cattle. Table 6.2, however, points out that although there is a positive

change in per capita per day consumption of vegetables after adoption of crossbred cattle but the change is not statistically significant. It is found that *ceteris paribus* adoption of crossbred cattle leads to approximately 164, 11, 7 and 8 grams increase in the per capita daily consumption of milk, fish, meat and fruits respectively (Table 6.2).

Table 6.2: Mean per capita Daily Consumption of High Value Commodities for the Sample Farmers and their Mean Difference Test

Outcome Variable	Treatment (N=137)		Comparisons (N=108)		t-test (2-tailed)	
	Mean	Std. error	Mean	Std. error	Difference	p-value
Consumption of Milk (gram)	308.690	16.209	144.574	11.469	164.116	0.000
Consumption of Fish (gram)	45.144	3.454	34.043	3.393	11.101	0.025
Consumption of Meat (gram)	22.259	2.180	15.279	1.109	6.980	0.009
Consumption of Vegetables (gram)	151.284	7.541	130.875	14.598	20.409	0.189
Consumption of Fruits (gram)	18.247	1.836	10.408	1.724	7.838	0.002

Source: Author's estimation based on field survey data;

Notes: p<0.01, p<0.05 and p<0.1 indicate significant at 1%, 5% and 10% respectively

Table 6.3 presents the summary statistics and mean difference test of outcome variables relating to employment potential for adopter and non-adopter of crossbred cattle. The outcome variables are the overall and gender classified labour use in rearing dairy animals among sample households. It is seen that adoption of high yielding crossbred cattle may significantly increase overall labour use to the extent of 13.97 (p=0.000) days per month.

Table 6.3: Mean Employment of Labour (Person days/month) for the Sample Farmers and their Mean Difference Test

Outcome Variable	Treatment (N=137)		Comparisons (N=108)		t-test (2-tailed)	
	Mean	Std. error	Mean	Std. error	Difference	p-value
Employment (male person days/month)	17.256	1.194	7.317	0.538	9.939	0.000
Employment (female person days/month)	8.429	0.535	4.398	0.353	4.030	0.000
Employment (total person days/month)	25.685	1.383	11.715	0.593	13.969	0.000

Source: Author's estimation based on field survey data;

Notes: p<0.01, p<0.05 and p<0.1 indicate significant at 1%, 5% and 10% respectively

Adoption of crossbred cattle also directly leads to significant increase of labour use for both male and female equivalent to 9.94 and 4.03 person days per month respectively. Thus the test of the equality of means between adopters and non-adopters of high yielding crossbred cattle signifies that adopters have significantly higher use of labour for both male and female members of the farm households compared to non-adopters.

The outcome variables of our interest indicating household wellbeing show that using sample mean difference test between adopters and non-adopters, there is found to have a positive impact after adoption of high yielding crossbred cattle for most of the variables in Table 6.1 to Table 6.3. However, these results cannot be used to make inferences regarding the impact of crossbred cattle adoption. This is because confounding factors should be controlled for to do away with selection bias as stated before. As Table 6.4 shows that the mean difference test for various farm characteristics that may influence both the outcome variable and adoption of crossbred cattle indicates that non-adopters are likely to be constrained in terms of household head's education, distance to all-weather road, herd size, credit access, information on improved breeding services such as AI, cooperative membership, accessing benefit from government dairy development programme, having a saving/bank account and average price of milk sold. It is seen that treatment group (adopter) is more educated compared to its comparison (non-adopter) group by an average years of schooling of 2.81 years and have lesser distance to all-weather road equivalent to 121.77 metres. Furthermore, treatment group is likely to have higher herd size of 7.16 cattle heads against the herd size of 5.39 cattle heads. The likelihood of access to credit and membership of dairy cooperative society for the adopters of crossbred cattle is larger vis-à-vis the non-adopters. Number of years since first knew about AI has been taken as a proxy for access to extension services and indicates that adopters have a better access to extension services and thus knew about AI much before over the knowledge of the non-adopter counterparts. It also appears that adopter households are more likely to be the beneficiary of government dairy development programmes (such as free distribution of fodder seeds and distribution of subsidized concentrates under RKVY). Average price of milk is considered as proxy to availability of better marketing facility in the farmer's locality and indicates that adopters have better and remunerative marketing facility compared to the non-adopter of crossbred cattle (Table 6.4). For all other variables (i.e., age of household head, family size, off-farm

income, distance to market and duration of the farm), the mean differences between the two groups are not statistically significant, implying that for these variables there is no selection bias in adoption of high yielding crossbred cattle.

Table 6.4: Descriptive Statistics for Explanatory Variables of Unmatched Sample (mean)

Explanatory Variables	Treatment (N=137)		Comparisons (N=108)		t-test (2-tailed)	
	Mean	Std. error	Mean	Std. error	Difference	p-value
Age of the Household head (years)	50.671	1.100	49.778	1.167	0.894	0.580
Education of the household head (number of years in school)	7.489	0.404	4.676	0.413	4.813	0.000
Family size (number of family members)	5.722	0.203	6.139	0.257	-0.416	0.198
Off-farm income (1=yes; 0=otherwise)	0.620	0.042	0.556	0.048	0.065	0.306
Distance to market (km)	2.853	0.136	3.148	0.161	-0.295	0.160
Distance to all-weather road (metre)	350.00	33.283	471.768	35.902	-121.767	0.014
Herd size (number of cattle)	7.161	0.736	5.389	0.357	1.772	0.047
Access to credit (1=yes; 0=otherwise)	0.212	0.035	0.111	0.030	0.100	0.036
Number of years since first knew about AI technology (years)	13.459	0.747	7.852	0.570	5.608	0.000
Membership of dairy cooperative society (1=yes; 0=otherwise)	0.459	0.043	0.111	0.030	0.349	0.000
Beneficiary of govt. dairy development programme (1=yes; 0=otherwise)	0.328	0.040	0.028	0.016	0.300	0.000
Having saving/ bank account (1=yes; 0=otherwise)	0.854	0.030	0.648	0.046	0.206	0.000
Price of milk sold (Rs/litre)	34.993	0.644	31.370	1.319	3.622	0.008
Duration of the farm (years)	27.540	1.274	27.194	1.396	0.346	0.855
Ethnicity dummies						
Bengali (1=yes; 0=otherwise)	0.255	0.037	0.352	0.046	-0.096	0.102
Nepali (1=yes; 0=otherwise)	0.379	0.042	0.287	0.044	0.092	0.129
Bihari (1=yes; 0=otherwise)	0.073	0.022	0.129	0.032	-0.057	0.139
Others (1=yes; 0=otherwise)	0.044	0.017	0.055	0.022	-0.012	0.673
District dummies						
Sonitpur (1=yes; 0=otherwise)	0.314	0.040	0.361	0.046	-0.047	0.438
Karbi Anglong (1=yes; 0=otherwise)	0.292	0.039	0.287	0.044	0.005	0.933

Source: Author's estimation based on field survey data;

Notes: $p < 0.01$, $p < 0.05$ and $p < 0.1$ indicate significant at 1%, 5% and 10% respectively

The incidence of adoption by farm size and education level of the household head is presented in Table 6.5. It is seen that the incidence of adoption is higher in case of average to small farmers (with less than 6 cattle heads) compared to large farm holders. It is found that of the 245 total sample farm households, almost 38 per cent average to small farm owners have adopted high yielding crossbred cattle while only 18 per cent large farm owners (with more than 6 cattle heads) have adopted crossbred cattle. It is again envisaged from Table 6.5 that there exists a positive association between education of the household head and adoption of high yielding crossbred cattle. According to Kassie et al. (2011), educated household head may have better access to information and may be better able to analyze the importance of the technology and manage new technologies efficiently. The proportion of farmers with high education adopting the high yielding crossbreds is 31 per cent against 25 per cent for the households with less than 6 years of schooling. The summary statistics and mean difference tests in Table 6.4 and Table 6.5 report that adopters of high yielding crossbred cattle may be systematically different from non-adopters which may be due to farmer's self-selection into treatment.

Table 6.5: Category of Households by Farm Size (number of cattle heads) and Education Status (per cent of total sample)

Household Category [#]	Adopters (N = 137)	Non-adopters (N = 108)
Large Farm size (> 6 cattle heads)	17.96	10.20
Average/small farm (≤ 6 cattle heads)	37.96	33.88
High education (> 6 years of schooling)	31.02	18.78
Low Education (≤ 6 years of schooling)	24.90	25.31

Source: Field Survey, 2015-16

Note: [#] classification is done with reference to higher/lower than the average years of schooling (5.99 years) and cattle heads owned by the farm households (6.38 numbers)

6.2.2. Estimation of Propensity Scores

The empirical analysis of the treatment impact begins with the probit estimation of propensity score where adoption of crossbred cattle in the probit model is coded as 1 for adopter and 0 for non-adopter. The selection of explanatory variables for adoption of crossbred cattle is drawn from some of the theoretical (Feder et al., 1985; Doss, 2006) and empirical literatures based on analysis of socio-economic factors influencing agricultural

technology adoption. A detailed explanation of the explanatory variables for Probit estimates of propensity score is given below.

Farmer characteristics such as age of the household head characteristics can be associated either positively or negatively with improved agricultural technology adoption. This may be due to the fact that older farmers are more experienced (Beshir, 2014) or younger farmers may be more innovative (Adesina and Baidu-Forson, 1995; Doss, 2006). Household characteristics such as education may positively influence adoption of crossbred cattle (Huffman, 2001). A literate household head may easily comprehend the likely benefit of adopting productivity enhancing technology. Studies have also shown that education of the household head can be a symbol of household's wealthiness and likely to bear a positive relation with new and improved agricultural technology adoption (Walker et al., 2004; Cunguara and Darnhofer, 2011). Family size of the household is included in the present study to model the crossbred cattle adoption considering that lack of labour may impair the use of labour intensive technology such as rearing of crossbred cattle (Mekonnen et al., 2009; Doss, 2006). Some studies include availability of assets as one of the determinants of new agricultural technology adoption. Participation in off-farm employment for the household head can be included as a suitable proxy to asset endowment (Walker et al, 2004) as farmers may be facilitated with meeting capital and/or operating expenses required in the new technology.

Some of the location characteristics such as distance to market (Baltenweck and Stall, 2000) and distance to all-weather road (Barett, 2008; Feder et al., 1985; Cunguara and Darnhofer, 2011) are likely to reduce constraints to information access and transaction costs. Farm households located close to the market and near to all-weather road may reduce transaction cost through easy access to input and output market and thus incentivize towards crossbred cattle adoption. Hence, there is a negative hypothesized relation between adoption of crossbred cattle and distance to market and distance to all-weather road from farm household. Farm size affects positively the adoption of new agricultural technology (Smale and Mason, 2013). In the present study also it is presumed that as farm size increases, the farmers may start adopting more high yielding crossbred cattle because this may help them in two ways: (i) having a capital base (through selling of low productive local cattle) to buy

relatively expensive crossbred cattle and/or (ii) through domestically growing of such breeds through impregnating the local female cattle with AI or using bull of high genetic merit (exotic). Credit is an important factor incorporated in Probit estimation of crossbred cattle adoption. Literatures point out that when initial investments in the adoption process of a new technology, access to credit may facilitate the technology adoption (Hazarika et al., 2016; Noltze et al., 2012; Shiferaw et al., 2008; Lapple et al., 2015). In a rural economy when expansion of crossbred technology (diffusion of crossbred cattle through purchase) is partially conditioned by the access to credit services, it is hypothesized that there is a positive relationship between adoption of crossbred cattle and access to financial services.

Access to information about new technology is included through two binary proxy variables: number of years since first knew about AI technology and membership of farmer's association such as DCS. The understanding is that farmers that knew about this technology had access to extension services much earlier than a farmer who has known the technology very recently. Also one can tap the advantage of social capital by becoming members of farmers association such as DCS where information likely to move very quickly among farmers (Cunguara and Darnhofer, 2011; Doss, 2006; Ramirez, 2013). Beneficiary of government dairy development programme affects positively the adoption of crossbred cattle. Farm households that have ever benefitted from such programme may get an incentive and support to adopt a new agricultural technology. The household's possession of a saving/bank account points out the financial inclusion status (Hazarika et al., 2016). Having a saving/bank account acts as a catalyst towards adoption of crossbred cattle through time sensitive AI technology adoption and thus may have positive effect on the same. Price of milk is an important indicator of expected profit ex-post the adoption of crossbreeding technology. A higher market price can act as an important signal of better marketing facilities and encourage farmers towards adoption of new technology and thus may positively affect adoption of crossbred cattle. Ethnicity and location dummy are included in the Probit model to control for heterogeneity arising due to differences in the crossbreeding technology adoption behaviour among farmers and to control for spatial heterogeneity of the sample households.

The probit estimates of the propensity equation are presented in Table 6.6. The model is significant at 1% probability level with LR Chi2 value 110.48 per cent and Pseudo R2 value of 0.3286. The log likelihood ratio is -112.86 and the model correctly predicts 78.70% of adopters and 79.56% of non-adopters. Table 6.6 indicates that many of the variables have the expected sign with some of the important variables such as herd size, number of years

Table 6.6: Probit Estimation of Determinants of Crossbred Cattle Adoption

Variables	Coefficient	Std. error	p-value
Age of the Household head (years)	0.0137	0.0099	0.169
Education of the household head (number of years in school)	0.030	0.0264	0.255
Family size (numbers of family members)	-0.0087	0.0456	0.849
Off-farm income (1=yes; 0=otherwise)	0.1228	0.2297	0.539
Distance to market (km)	-0.0529	0.0672	0.431
Distance to all-weather road (metre)	-0.00009	0.0002	0.712
Herd size (number of cattle)	0.0619	0.0325	0.057
Access to credit (1=yes; 0=otherwise)	-0.0028	0.3132	0.993
Number of years since first knew about AI technology (years)	0.0790	0.0184	0.000
Membership of dairy cooperative society (1=yes; 0=otherwise)	1.0372	0.3202	0.001
Beneficiary of govt. dairy development programme (1=yes; 0=otherwise)	1.0252	0.3927	0.009
Having saving/ bank account (1=yes; 0=otherwise)	0.2082	0.2468	0.399
Price of milk sold (Rs/litre)	0.0220	0.0110	0.046
Duration of the farm (years)	-0.0202	0.0089	0.024
Ethnicity dummies			
Bengali (1=yes; 0=otherwise)	0.4933	0.3630	0.174
Nepali (1=yes; 0=otherwise)	0.3984	0.4182	0.341
Bihari (1=yes; 0=otherwise)	0.1488	0.4996	0.766
Others (1=yes; 0=otherwise)	0.6485	0.5941	0.275
District dummies			
Sonitpur (1=yes; 0=otherwise)	-0.9621	0.3701	0.009
Karbi Anglong (1=yes; 0=otherwise)	0.0199	0.4008	0.960
Constant	-2.4854	0.7502	0.001
LR Chi2 (20)		110.48	
Prob>Chi2		0.000	
Pseudo R2		0.3286	
Log likelihood		-112.86	
Non-adopters correctly predicted		79.56%	
Adopters correctly predicted		78.70%	
No. of observations		245	

Source: Author's estimation based on field survey data

Notes: $p < 0.01$, $p < 0.05$ and $p < 0.1$ indicate significant at 1%, 5% and 10% respectively

since knowing about artificial insemination (AI), membership of Dairy Cooperative Society (DCS), beneficiary of government dairy development programme, and price of milk sold are found to significantly and positively influence adoption of high yielding crossbred cattle. Duration of the farm that significantly affects adoption of crossbred cattle is having a negative association with the dependent variable. It is found from Table 6.6 that as herd size increases by one cattle head, probability of crossbred cattle adoption increases by 6.19 per cent. Membership of DCS and becoming beneficiary of government dairy development programme have a stronger influence on adoption of crossbred cattle. It has been found that farmers with membership of DCS and availing the services of any government dairy development programme leads to respectively 103.72 and 102.52 per cent higher chances of crossbred cattle adoption. The other two significant variables, price of milk sold and duration of farm imply that with one rupee increase in the price of milk and one additional year increase in the duration of the farm lead to 2.2 per cent increase and 2.02 per cent decrease in the probability of crossbred cattle adoption respectively (see Table 6.6).

6.2.3. Covariate Balancing Test

Before going to the causal effect of adoption of high yielding crossbred cattle, we want to discuss the quality of matching process. Estimating the individual propensity score for the observations in the sample by implementing probit model the common support condition is checked. The estimated propensity scores range from close to zero (0.0125031) to close to one (0.9999) with a mean of 0.5592184 and a standard deviation of 0.3052. It is found that there is considerable overlap in common support condition as the predicted propensity scores for adopters of high yielding crossbred cattle ranges from 0.068306 to 0.9999 with a mean of 0.7276378 and a standard deviation of 0.2483 and for non-adopters, it ranges from 0.0125031 to 0.9114233 with a mean of 0.3455754 and a standard deviation of 0.2273. Thus, following the minima and maxima criteria, the common support region for the estimated propensity scores distribution of the sample farmers would lie in the range of 0.068306 to 0.9114233. In the process of overlapping the common support about 18.37 per cent of the total observations whose propensity scores lie outside the region of common support are discarded from the analysis that follows. This intersection region for the propensity score is also clear from the common support graph (Figure 6.1) as well. Figure

6.1 gives the histogram based on the estimated propensity scores for both adopters and non-adopters. The bottom half of the graph shows the propensity scores distribution for the non-adopters and upper half for adopters and the densities of the scores are represented in the y-axis. A cursory look of propensity scores density distributions for the two adoption groups indicate that the common support condition is satisfied, i.e., there is substantial overlap in the distribution of the propensity scores for the two groups (adopters and non-adopters).

As mentioned above, a major objective of propensity score estimation is to match the distribution of relevant variables between the two adoption groups, i.e., adopters and non-adopters, rather than obtain a precise prediction of selection into treatment. According to DING et al. (2011), three features that explain a good matched samples are that (a) the covariates incorporated in the propensity score estimation model (probit or logit) are good predictors of the treatment variables; (b) it retains a large percentage of the treated observations after implementation of common support, and (c) the individual variables used to match adopters and non-adopters are adequately 'balanced' across treatment and control groups.

As far (a) and (b) is concerned, the present study fulfils such conditions as discussed above and so far (c) is concerned we tried to see if individual variables used to match the two adoption groups (adopters and non-adopters) are adequately balanced across treated and non treated (control) groups based various matching estimators as suggested by several authors (Smith and Todd, 2005; Dehejia and Wahba, 2002; Calendo and Copening, 2005). Hence, in the present study we implemented matching estimators such as nearest neighbour matching, kernel matching, and radius matching using propensity score matching algorithms developed by Leuven and Sianesi (2003) in STATA 14. Theoretical literatures on PSM suggests few properties for a good matching between treatment and control group and satisfaction of it indicates that the two groups are similar and we can postulate a counterfactual situation. Firstly, it generates statistically identical covariate means for both groups (Caliendo and Kopeinig, 2005) and provides from a relatively high pseudo- R^2 value before matching to a low pseudo- R^2 value after matching (Sianesi, 2004) along with statistically insignificant likelihood ratio test of all regressors after matching (Smith and Todd, 2005). More specifically, rejection of the group means difference test after matching implies a good

balancing of the covariates. Secondly, reduction of mean standardised bias by a more than 20 per cent indicates that the matching process has failed Rosenbaum and Rubin (1983).

Table 6.7 and Table 6.8 presents that balancing property is satisfied between the distribution of covariates of adopters and non-adopters of crossbred cattle. In particular, mean equality tests of covariates between adopter households and their corresponding non-adopters shows that the two adoption groups are comparable. As one can see in Table 6.7, the unmatched

Table 6.7: Covariate Balancing Tests for Matched Sample

Variable	Unmatched sample			Five-nearest neighbor matching		
	Treated	Control	Diff: <i>p</i> -value	Treated	Control	Diff: <i>p</i> -value
Age of the Household head	50.672	49.778	0.581	49.207	50.707	0.453
Education of the household head	6.810	4.963	0.002	6.021	5.476	0.406
Family size	5.723	6.138	0.199	5.750	5.737	0.969
Off-farm income	0.620	0.556	0.307	0.641	0.913	0.301
Distance to market	2.853	3.148	0.161	2.883	2.933	0.854
Distance to all-weather road	350.0	471.77	0.014	385.33	436.33	0.361
Herd size	7.160	5.388	0.047	6.152	6.417	0.710
Access to credit	0.213	0.111	0.036	0.119	0.128	0.859
Number of years since first knew about AI technology	13.46	7.852	0.000	10.163	10.748	0.549
Membership of dairy cooperative society	0.459	0.111	0.000	0.271	0.241	0.639
Beneficiary of govt. dairy development programme	0.328	0.028	0.000	0.108	0.074	0.416
Having saving/ bank account	0.854	0.648	0.000	0.793	0.821	0.629
Price of milk sold	34.993	31.370	0.009	35.082	35.396	0.814
Duration of the farm	27.540	27.194	0.855	26.717	27.854	0.599
Ethnicity dummies						
Bengali	0.255	0.352	0.102	0.369	0.386	0.809
Nepali	0.379	0.287	0.130	0.293	0.326	0.635
Bihari	0.073	0.129	0.140	0.097	0.065	0.422
Others	0.043	0.556	0.673	0.065	0.045	0.564
District dummies						
Sonitpur	0.314	0.287	0.933	0.261	0.258	0.973
Karbi Anglong	0.292	0.287	0.933	0.336	0.345	0.902

Source: Author's estimation based on field survey data

Notes: $p < 0.01$, $p < 0.05$ and $p < 0.1$ indicate significant at 1%, 5% and 10% respectively

sample does not show that the balancing property is satisfied although the groups are found to be comparable in terms of age, family size, off-farm income, distance to market, duration of the farm and ethnicity and district dummies, a significant difference is found between the two adoption groups for the majority of the observed covariates before matching. The results of matching using five-nearest neighbour matching algorithm indicates that the observed covariates do not vary between the treated and control group in a statistically significant way. Covariate balancing test using kernel based matching (KBM) and radius matching (RM) is shown in Appendix Table A6.1 and Table A6.2 and the results do not vary in a significant way from five-nearest neighbour matching.

Table 6.8 presents the results of the covariate balancing tests based on the above mentioned indicators using various matching algorithms. The Pseudo-R² before matching was 32.9% before matching gets reduced to 1.6 – 2.5% after matching. Again, the *p*-values of the likelihood ratio tests (joint significance of covariates) was significant and never rejected before matching is always rejected after matching. The standardised mean difference for the covariates used in the propensity score of around 29.2% before matching is reduced to about 4.4-6.8% after matching. This reduces total bias substantially in the range of 76.71 – 84.93%. It is further observed that the number of observations retained after matching are 200 from a total of 245 observations and indicates that the matching process did not result to substantial loss of observations (see Table 6.8).

Table 6.8: Indicators of Matching Quality Before and After Matching

Matching algorithm	Pseudo R ² before matching	Pseudo R ² after matching	LR χ^2 (p-value) before matching	LR χ^2 (p-value) after matching	Mean standardized bias before matching	Mean standardized bias after matching	Total % bias reduction
NNM ^a	0.329	0.025	110.48 (p=000)***	6.29 (p=0.998)	29.2	6.8	76.71
KBM ^b	0.329	0.018	110.48 (p=000)***	4.70 (p=1.000)	29.2	5.2	82.19
RM ^c	0.329	0.016	110.48 (p=000)***	4.03 (p=1.000)	29.2	4.4	84.93

Source: Author's estimation based on field survey data;

Note: *** Significant at 1% probability level

^a NNM = five nearest neighbor matching with replacement and on common support

^b KBM = kernel based matching with band width 0.06 and on common support

^c RM = radius matching with caliper 0.1 and on common support

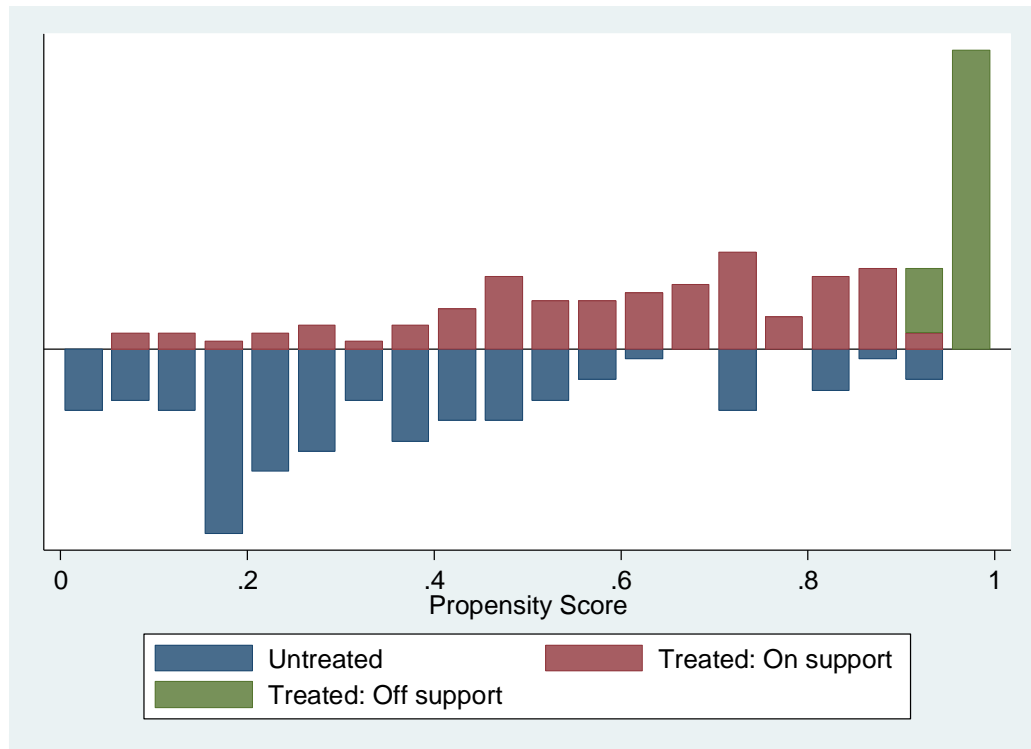


Figure 6.1: Distribution of propensity scores and estimation of common support for propensity scores. **Note:** “Treated: on support” indicates the observation of high yielding crossbred cattle adoption group that have suitable comparison. “Treated: off support” indicates the observation of high yielding crossbred cattle adoption groups that do not have suitable comparisons.

6.3. Estimation of Treatment Impact

The estimated treatment effects on the treated using NNM, KBM and RM estimators are shown in Table 6.9. Different matching estimators such as five nearest neighbor matching and Epanechnikov kernel based matching with bandwidth 0.06 and radius matching with caliper 0.1 have been used to see consistency of the treatment effects. Common support is implemented for all the matching estimators so that the propensity scores distributions for adopters and non-adopters lie in the same domain. The significance of outcome variables (outcome differences of adopters over non-adopters) is based on ‘z’ value obtained from bootstrapping of standard errors using 50 replications.

Table 6.9: Estimation of ATT: Impact of Crossbred Cattle Adoption on Income and Consumption

Outcome Variables	NNM (5)	KBM (0.06)	RM (0.1)
	ATT (Income in Rs)		
Crop and/or plantation income/annum	7141.96 (0.88)	8754.88 (1.07)	8220.47 (1.01)
Net dairy income [#] /annum	44716.90*** (6.02)	44573.03*** (6.27)	44904.27*** (6.29)
Livestock income [@]	1526.96 (0.98)	1774.98 (1.09)	1715.44 (1.12)
Off-farm income/annum	1003.26 (0.04)	-7244.93 (0.29)	-8540.64 (0.29)
Total Household Income	54389.08* (1.87)	47857.96* (1.84)	46299.54* (1.83)
Net dairy income [#] /milch cattle/day	42.06*** (7.07)	42.14*** (7.62)	42.21*** (8.13)
Outcome Variables	ATT (Per Capita Daily Consumption in grams)		
Milk consumption	105.87*** (4.71)	109.55*** (3.76)	106.17*** (3.85)
Fish consumption	5.37 (0.77)	5.79 (0.82)	4.53 (0.67)
Meat consumption	8.40* (1.75)	7.09* (1.73)	6.51* (1.91)
Vegetable consumption	-1.23 (0.02)	11.45 (0.27)	-0.26 (0.00)
Fruit consumption	2.07 (0.36)	1.03 (0.20)	-0.74 (0.13)
Outcome Variables	ATT (Labour use in person days/month)		
Male	6.31*** (4.65)	6.04*** (4.48)	6.10*** (5.02)
Female	4.24*** (4.74)	4.22*** (4.63)	4.34*** (5.29)
Total	10.55*** (6.22)	10.27*** (6.60)	10.44*** (6.11)

Source: Author's estimation based on field survey data;

Note: [#]Net dairy income is calculated as: gross value from milk and milk product sale + imputed value of domestically consumed milk minus the paid out cost; [@] Livestock income includes the selling of livestock products (other than milk and milk products) such as live animals, cow dung, eggs etc.; ATT estimates of all matching algorithms are obtained by implementing 'psmatch2' command (Leuven and Sianesi, 2003) in STATA 14; Figures in parentheses indicate bootstrapped z value using 50 replications; *, ** and *** indicate significant at 10%, 5% and 1% probability level respectively;

NNM (5) = five nearest neighbour matching with replacement and common support

KBM (0.06) = kernel based matching with bandwidth 0.06 and common support

RM (0.1) = radius matching with caliper 0.1 and common support

The outcome variables to represent wellbeing of the farm households are the household income by different sources after adoption of crossbred cattle, per capita consumption of high value commodities, and employment of labour (increased labour use). Although the various matching estimators provide slightly different quantitative results for the statistically significant outcome variables in Table 6.9 but qualitatively crossbreeding technology adoption effects are same across all the matching estimators. The significant increase (p -value = 0.000) in net dairy income per annum after adoption of crossbred cattle ranges from Rs 44,573.03 to Rs 44,904.27 (see Table 6.9) for the different matching estimators. Normalizing the net dairy income in terms of per milch cattle per day, the significant increase (p -value = 0.000) after adoption of crossbred cattle is estimated in the range of Rs 42.06 to Rs 42.21. Dairy income being the dominant component of farm households showing highly significant rise after adoption of high yielding crossbred cattle, the total household income also shows significant change (at the 10% probability level) for adopters vis-à-vis the matched non-adopters of crossbred cattle. The total household income is found to increase in the range of Rs 46299.54 to Rs 54389.08 after adoption of crossbred cattle. The other income components of the total household income, namely crop and/or plantation income and livestock income display a positive but statistically non-significant change after adoption of crossbred cattle.

The average treatment effects on the treated after adoption of high yielding crossbred cattle for average per capita daily consumption of high value food commodities indicate a positive and significant increase for consumption of milk and meat. Adopter households have higher average per capita daily consumption by a range of 105.87 to 109.55 grams of milk and milk products and 6.51 to 8.40 grams of meat. The differences in average fish consumption between similar pairs of households belonging to different technological status (adopters and non-adopters of cattle crossbreeding) are positive but found to be statistically non-significant. Moreover, the changes in per capita daily consumption of vegetables and fruits are found to be positive for specific matching estimators only (KBM for vegetable consumption and NNM and KBM for fruit consumption)

Another outcome variable considered as indicator of household wellbeing is the increased labour use of adopters of crossbred cattle over the matched non-adopters. Studies indicate

that as the total change in milk output is positive and high with the adoption of new dairy technology such as crossbred cattle the net effect is that of increasing employment (Lalwani, 1987). It is seen from Table 6.9 that adopters are found to have statistically significant increase in total labour use after high yielding crossbred cattle adoption equivalent to the range of 10.27 to 10.55 person days per month ($p=0.000$) in relation to the matched non-adopters. Of the changes in monthly total person days, significant rise in male and female person days is constituted in the range of 6.04 to 6.31 ($p=0.000$) and 4.22 to 4.34 person days per month ($p=0.000$) respectively.

These findings are consistent with some of the recent studies on impact of adoption of modern agricultural varieties such as studies carried out by Hossain et al. (2006) in Bangladesh, Kassie et al. (2011) in Uganda and Amare et al. (2012) in Tanzania.

6.4. Treatment Heterogeneity

In order to have further understanding of the heterogeneous effect of high yielding crossbred cattle adoption across education and farm size, households are divided into higher and lower than the average years of schooling (education group) and average cattle heads owned (farm size group) based on matched samples implementing all the three matching algorithms (NNM, KBM and RM) (see Table 6.10 for the results). The outcome variables are judiciously selected to understand impact heterogeneity considering that the same variables are important to represent farm household's income, labour use and consumption of high value commodities. These outcome variables are highly significant in the estimation of ATT in Table 6.9. It is evident from Table 6.10 that the income effect (rise in net dairy income) after adoption of crossbred cattle increases with the increase in farm size and level of education. The increase in annual net dairy income for the adopter households are in the range of Rs 58320.20 to Rs 59508.54 for the large farms compared to its matched non-adopters against the small to average farms (with less than 6 cattle heads) with a range of Rs 39896.75 to Rs 40177.31. Similarly, educated households have significantly higher farm income in the range of Rs 62966.87 to Rs 78300.08 compared to its non-adopter counterpart. The increase in net dairy income for farms with household head's low education is in the range of Rs 36069.57 to Rs 36875.64 compared to the counterfactual non-adopters. The

higher net dairy income for the high educated adopter farms may be due to their ability to process the information on high yielding cattle rearing practices resulting to better farm management capacity. Table 6.10 further shows that the overall labour absorption is higher by a small margin in case of large adopter farmers compared to its matched non-adopters (in the range of 11.55 to 12.05 person days/month) against the small to average farmers (10.01 to 10.26 person days/month). Similarly, increase in total labour absorption of adopters with higher than average education of the household head is much higher (in the range of 13.20 to 13.93 person days/month) against the matched comparisons of adoption group with lesser than the average education of household head (9.74 to 10.41 person days/month). The pattern is partially consistent with the findings of Kassie et al. (2011) which is based on impact of agricultural technology adoption on crop income and poverty alleviation in Uganda. However, one interesting finding in Table 6.10 is that, according to farm size category, smallholder farmers have significantly ($p < 0.01$) higher effect on per capita daily consumption of milk after adoption of crossbred cattle. It has also been noted that members of low educated crossbred cattle adopter farm households drink significantly more milk compared to its matched non-adopter farm households. All the matching algorithms show statistically insignificant increase in per capita daily consumption of milk for farm households with higher than the average education level and larger than average farm size (except using RM). These results suggest that effect of dairy income and employment will be more in case of relatively larger farmers and farmers with higher than the average education level of household. It can also be suggested that smallholder farmers may be better able to supplement their nutritional needs by consuming more milk once they adopt high yielding crossbred cattle.

Table 6.10: Differential Impact of Crossbred Cattle Adoption Disaggregated by Farm Size and Education Level of Household head

Stratification	ATT					
	Net Dairy Income (Rs/annum)		Total Employment (person days/month)		Milk Consumption (Gram/person/day)	
Stratified by Farm Size						
	Large farm (>6 cattle heads)	Small Farm (≤ 6 cattle heads)	Large farm (>6 cattle heads)	Small Farm (≤ 6 cattle heads)	Large farm (>6 cattle heads)	Small Farm (≤ 6 cattle heads)
NNM (5)	59198.13*** (3.35)	40177.31*** (5.84)	11.73** (2.11)	10.26*** (5.96)	104.18 (1.78)	111.89*** (3.48)
KBM (0.06)	58320.20* (1.71)	39896.75*** (5.14)	11.55 (1.46)	10.01*** (6.17)	96.93 (1.63)	104.93*** (3.75)
RM (0.1)	59508.54*** (4.18)	40175.45*** (5.74)	12.05*** (10.22)	10.08*** (6.49)	100.20* (1.70)	103.81*** (3.89)
Stratified by education level of Household head						
	High education (> 6 years of schooling)	Low education (≤ 6 years of schooling)	High education (> 6 years of schooling)	Low education (≤ 6 years of schooling)	High education (> 6 years of schooling)	Low education (≤ 6 years of schooling)
NNM (5)	62966.87*** (2.18)	36069.57*** (4.36)	13.20*** (3.30)	10.03*** (4.32)	62.93 (1.13)	100.18*** (3.31)
KBM (0.06)	78300.08*** (2.68)	36660.15*** (4.36)	13.72*** (4.23)	10.41*** (4.01)	93.29 (1.54)	99.00*** (3.64)
RM (0.1)	66657.05*** (3.19)	36875.64*** (4.03)	13.93*** (3.46)	9.74*** (4.17)	55.34 (0.85)	92.01*** (2.82)

Source: Author's estimation based on field survey data;

Notes: Figures in parentheses indicate bootstrapped z value using 50 replications; significant * at 10%, ** at 5% and *** at 1% probability level;

NNM (5) = five nearest neighbour matching with replacement and common support

KBM (0.06) = kernel based matching with bandwidth 0.06 and common support

RM (0.1) = radius matching with caliper 0.1 and common support

6.5. Robustness Check

It is tried to check the sensitivity of the estimated treatment effects to changes in the specification of the probit estimates of propensity score. There are studies (Smith and Todd, 2005; Heckman et al., 1998; Kassie et al., 2011) that show that matching estimates can be sensitive to changes in propensity score specification. In the absence of experimental benchmark estimate, sensitivity of the estimated results with the changes in propensity score specification is the most basic check a research should perform (Dehejia, 2005)

Following Kassie et al. (2011) and Abate et al. (2016) three propensity scores specifications for sensitivity checks are carried out by incorporating higher order variables such as squared term of age and education with the explanatory variables of the original propensity score specification and reduced probit model specification. In the first specification (column 1), age squared is included as additional covariate in the set of original explanatory variables in the probit estimates of propensity score indicated in Table 6.11, while in the second specification (column 2) both age and education squared term are included as additional covariates. The third specification (column 3) uses reduced probit model specification for probit estimation of propensity scores by excluding potentially endogenous variables such as, education of the household head, family size, off-farm income and farm size from the original specifications. The matching quality for the estimation of ATT using all the three propensity scores specification is presented in Appendix Table A6.3.

The comparison of the results are reported in Table 6.11. The estimates are obtained using five nearest neighbour matching (5 NNM) with replacement. Consistent results are also found by using other two matching algorithms (KBM and RM) and thus it has not been

Table 6.11: Robustness of Average Treatment Effects on the Treated (ATT) Results for Crossbred Cattle Adoption

Outcome variables	Treatment variable: Adoption of crossbred cattle		
	First specific.	Second specific.	Third specific.
	NNM (5) ATT	NNM (5) ATT	NNM (5) ATT
Net Dairy Income (Rs/annum)	50184.52*** (5.87)	50163.85*** (6.14)	48658.40*** (6.52)
Total Employment (Person days/month)	10.93*** (6.56)	10.85*** (6.95)	10.66*** (6.20)
Milk Consumption (Gram/person/day)	118.91*** (5.15)	116.45*** (4.76)	124.23*** (4.90)
Number of observations	216	216	207

Source: Author's estimation based on field survey data;

Notes: Figures in parentheses indicate bootstrapped z value using 50 replications; significant * at 10%, ** at 5% and *** at 1% probability level; after imposing common support condition, the matched samples include 108 of adopters (treatment) and 108 for non-adopters (comparison) for specification 1 and 2 and 108 adopters of crossbred cattle (treatment) and 99 non-adopters (comparison) for matching based on the specification 3.

NNM (5) = five nearest neighbour matching with replacement and common support

reported. It is seen from Table 6.11 that the estimates of outcome variables are reasonably robust to alternative propensity scores specification (i.e., results are insensitive to propensity score specification). Outcome variables are found to be similar with the original propensity score specifications (Table 6.9) both qualitatively in their values and significance level. The outcome variable, annual net dairy income shows highly significant increase after adoption of crossbred cattle ranging from Rs. 48658.40 to Rs. 50184.52 ($p=0.000$). The other two outcome variables showing statistically significant change after high yielding crossbred cattle adoption indicate that there is a monthly 10.55 to 10.93 person days increase ($p=0.000$) in labour absorption and per capita consumption of milk in the range of 105.87 to 124.23 grams ($p=0.000$). Thus, it is seen that our results display stability to different propensity score specifications as the range of changes in the outcome variables are for comparisons of propensity scores specifications in the original and the alternatives.

6.6. Summing Up

Treatment impact of crossbreeding technology adoption on farmers' wellbeing indicators such as income, employment and consumption of high value commodities are analyzed using semi-parametric technique, namely propensity score matching. One major advantage of using this analytical method is its ability to address selection bias over the other methods as the adopters of crossbred cattle, given their observable variables, may be systematically different from non-adopters. It is found from the discussions in the present chapter that using three matching estimators such as NNM, KBM and RM and implementing common support there is a significant (p -value = 0.000) increase in the annual net dairy income of adopters after adoption of crossbred cattle compared to its matched non-adopters in the range of Rs 44,573.03 to Rs. 44,904.27. Normalizing the net dairy income in terms of per milch cattle per day, adoption of crossbred cattle has led to the increase of income in the range of Rs 42.06 to Rs 42.21. Dairy income being the dominant component of total household income of cattle rearing farmers leading to highly significant change after adoption of crossbreeding technology, the increase in total household income also found to be significant. The other income components of the total household income, namely crop and/or plantation income and livestock income show a positive but statistically non-significant change after adoption of crossbred cattle. It is also found from the above discussion that crossbred cattle adopters

have significantly higher average per capita daily consumption of high value commodities such as milk (in the range of 105.87 to 109.55 grams) and meat (in the range of 6.51 to 8.40 grams). The other important outcome variable of our concern is the increased labour use after adoption of crossbred cattle over the matched non-adopters. Analyses show that adopters are found to have statistically significant increase in total labour use after high yielding crossbred cattle adoption equivalent to the range of 10.27 to 10.55 person days per month (p -value=0.000) in comparison to the matched non-adopters. Similar results are reported in studies such as Hossain et al. (2006), Kassie et al. (2011) and Amare et al. (2012). Analyses are made also on treatment heterogeneity by the size of farm and level of education of the household head. It is found that the rise in net dairy income after adoption of crossbred cattle increases with the increase in farm size and level of education. It is also seen that increase in total labour absorption of adopters with higher than average education of the household head is much higher against the matched comparisons of adoption groups with lesser than the average education of household head. Furthermore, it is found that, according to farm size category, smallholder farmers have significantly higher effect on per capita daily consumption of milk after adoption of crossbred cattle. It is surprisingly noted that members of low educated crossbred cattle adopter farm households drink significantly more milk compared to its matched non-adopter farm households. The robustness of ATT estimates of the significant outcome variables are checked using three different propensity score specifications and it is found that the results display stability to alternative propensity score specifications.

As it has rightly been pointed out of having positive wellbeing impact on farm households after crossbred cattle adoption, the issue that becomes important is to diffuse this technology to the the majority of the farm households in the state. The analyses of secondary data in chapter three points out that the penetration level of AI technology which is the important scientific invention for cattle crossbreeding is not up to the mark in Assam. Therefore, it is important to identify the factors that influence adoption of AI technology at farm-household level. In the next chapter, an attempt is made to identify the various farm, farmer, physical environment at which farmers operate and perception factors that influence adoption and extent of adoption of AI technology.

Notes:

1. Matching with replacement involves a trade-off between bias and variance. Allowing replacement increases quality of matching and decreases bias. This is of particular interest with data where the propensity score distribution is very different in the treatment and the control group (For more see Caliendo and Kopeinig, 2005)

2. During the survey period, 68.80 Indian Rupee (Rs) was equivalent to 1.00 US Dollar.



Appendix – 6.1

Table A6.1: Covariate Balancing Tests for Matched Sample

Variable	Unmatched sample			Kernel based matching		
	Treated	Control	Diff: <i>p</i> -value	Treated	Control	Diff: <i>p</i> -value
Age of the Household head	50.672	49.778	0.581	49.207	50.393	0.554
Education of the household head	6.810	4.963	0.002	6.022	5.741	0.674
Family size	5.723	6.138	0.199	5.75	5.776	0.938
Off-farm income	0.620	0.556	0.307	0.641	0.709	0.325
Distance to market	2.853	3.148	0.161	2.883	2.938	0.842
Distance to all-weather road	350.0	471.77	0.014	385.33	433.01	0.386
Herd size	7.160	5.388	0.047	6.152	6.307	0.826
Access to credit	0.213	0.111	0.036	0.119	0.124	0.919
Number of years since first knew about AI technology	13.46	7.852	0.000	10.163	10.573	0.667
Membership of dairy cooperative society	0.459	0.111	0.000	0.271	0.249	0.728
Beneficiary of govt. dairy development programme	0.328	0.028	0.000	0.108	0.081	0.536
Having saving/ bank account	0.854	0.648	0.000	0.793	0.792	0.989
Price of milk sold	34.993	31.370	0.009	35.082	35.323	0.859
Duration of the farm	27.540	27.194	0.855	26.717	27.404	0.749
Ethnicity dummies						
Bengali	0.255	0.352	0.102	0.369	0.347	0.759
Nepali	0.379	0.287	0.130	0.293	0.325	0.641
Bihari	0.073	0.129	0.140	0.097	0.079	0.668
Others	0.043	0.556	0.673	0.065	0.070	0.897
District dummies						
Sonitpur	0.314	0.287	0.933	0.260	0.256	0.944
Karbi Anglong	0.292	0.287	0.933	0.336	0.369	0.646

Notes: $p < 0.01$, $p < 0.05$ and $p < 0.1$ indicate significant at 1%, 5% and 10% respectively; **Source:** Author's estimation based on field survey data

Table A6.2: Covariate Balancing Tests for Matched Sample

Variable	Unmatched sample			Radius matching		
	Treated	Control	Diff: <i>p</i> -value	Treated	Control	Diff: <i>p</i> -value
Age of the Household head	50.672	49.778	0.581	49.207	50.228	0.970
Education of the household head	6.810	4.963	0.002	6.021	5.877	0.831
Family size	5.723	6.138	0.199	5.750	5.759	0.977
Off-farm income	0.620	0.556	0.307	0.641	0.727	0.210
Distance to market	2.853	3.148	0.161	2.883	2.943	0.825
Distance to all-weather road	350.0	471.77	0.014	385.33	419.3	0.539
Herd size	7.160	5.388	0.047	6.152	6.177	0.971
Access to credit	0.213	0.111	0.036	0.119	0.127	0.868
Number of years since first knew about AI technology	13.46	7.852	0.000	10.163	10.666	0.597
Membership of dairy cooperative society	0.459	0.111	0.000	0.271	0.265	0.925
Beneficiary of govt. dairy development programme	0.328	0.028	0.000	0.108	0.094	0.744
Having saving/ bank account	0.854	0.648	0.000	0.793	0.780	0.835
Price of milk sold	34.993	31.370	0.009	35.082	35.118	0.979
Duration of the farm	27.540	27.194	0.855	26.717	27.641	0.665
Ethnicity dummies						
Bengali	0.255	0.352	0.102	0.369	0.355	0.839
Nepali	0.379	0.287	0.130	0.293	0.325	0.645
Bihari	0.073	0.129	0.140	0.097	0.089	0.851
Others	0.043	0.556	0.673	0.065	0.056	0.800
District dummies						
Sonitpur	0.314	0.287	0.933	0.260	0.282	0.748
Karbi Anglong	0.292	0.287	0.933	0.336	0.342	0.940

Notes: $p < 0.01$, $p < 0.05$ and $p < 0.1$ indicate significant at 1%, 5% and 10% respectively; **Source:** Author's estimation based on field survey data

Table A6.3: Indicators of Matching Quality Before and After Matching

Matching algorithm	Pseudo R ² before matching	Pseudo R ² after matching	LR χ^2 (p-value) before matching	LR χ^2 (p-value) after matching	Mean standardized bias before matching	Mean standardized bias after matching	Total % bias reduction
Speicific. 1	0.336	0.046	112.90 (p=000)***	13.73 (p=0.881)	28.2	8.6	69.50
Speicific. 2	0.336	0.050	112.92 (p=000)***	14.87 (p=0.868)	28.8	8.9	69.10
Speicific. 3	0.312	0.022	104.85 (p=000)***	6.16 (p=992)	29.7	7.9	73.40

Source: Author's estimation based on field survey data

Note: *** indicats significant at 1% probability level;





CHAPTER SEVEN

DETERMINANTS OF CROSSBREEDING TECHNOLOGY ADOPTION AND FARMERS' PERCEPTION ON CONSTRAINTS

In the preceding chapter impact of crossbred cattle adoption on farmers' various wellbeing indicators such as income, consumption of protein rich high value food and employment (increased labour use) are analyzed employing semi-parametric analytical technique such as propensity score matching. The findings based on three matching estimators such as NNM, KBM and RM indicates that crossbred cattle adoption has higher impact on net dairy income and so also the total household income (net dairy income being the dominant source of the total household income). The chapter also points out of having higher per capita daily consumption of milk and meat for adopter farmers over the counterfactual non-adopters. Outcome indicator such as employment shows that adoption of crossbred cattle leads to higher requirement of total person days per month compared to the matched non-adopters indicating that crossbreeding technology adoption is associated with higher employment opportunity. Based on the analysis of secondary data (in chapter three) available at government departments and milk production and productivity characteristics of the sample farmers (in chapter five), it is found that increase in the dairy productivity may be realized only through genetically improving the low productive indigenous cattle stock towards high yielding crossbred cattle. AI technology which is the significant scientific invention for changing the genetic makeup of the cattle stock for making high yielding crossbred cattle must, therefore, be diffused at farmers' level. But compared to many states in India, the adoption rate of AI technology is significantly low in Assam. Important factors that influence the adoption of AI technology must therefore be identified so that policy prescription may be made to work on those factors determining adoption decision and intensity of use of AI technology. Hence, in the following sections, an attempt is made to identify the determinants of AI technology adoption at farmer's level by using appropriate micro-econometric model of agricultural technology adoption.

The rest of the chapter is organized in six sections. Section 5.1 discusses the econometric specification of agricultural technology adoption model. The analytical and empirical model

of AI technology adoption has been specifically discussed in this section. Section 5.2 elaborates the measurement and definitions of variables for adoption and intensity of adoption of AI technology. Section 5.3 deals with the description of explanatory factors of empirical adoption model. Discussion on the econometric results for AI technology adoption that includes model specification, diagnostic tests and factors influencing adoption and extent of adoption of AI technology is reported in section 5.4. While section 5.5 discusses farmers' perception on constraints to adoption of crossbreeding technology, section 5.6 finally sums up the whole discussion of the chapter.

7.1. Econometric Specification of Agricultural Technology Adoption Model

7.1.1. The Analytical Model

Adoption refers to a decision at the individual farmer level subject to various constraints such as credit and information (Feder and Umali, 2003). The diffusion of information literature (Roger, 1983; Feder et al., 1985) has slightly taken a turn towards adoption decision, i.e., whether to adopt a new technology or not and further if adopted then to what extent, i.e. the intensity of adoption (Kaaya et al., 2005; Tefera et al., 2014; Rehman et al., 2007; Awotide et al., 2014; Beshir et al., 2012). The intensity of adoption is implied as the aggregate use level of a given technology within a household (Feder et al., 1985).

Farmers make technology adoption decision based on the objective of utility maximization (Rahm and Huffman, 1984). Let the technology index is denoted by k , where $k = 1$ for the old technology and $k = 2$ for the new technology. The preference for a technology (new or sticking to old) depends on a non-observable underlying utility function $U(H_{ki}, T_{ki})$. Utility derivable from new technology depends on H_k , which implies the vector of farm, farmer and physical environment characteristics at which the farmer operates and T_k which is a vector of attributes embodied in the technology itself. The utility function, albeit unobserved, a linear relationship is postulated between the utility derivable from the k^{th} technology and a vector of observed farm, farmer and physical environment specific characteristics (e.g. experience in dairying, size and physical location of the farm, institutional access etc.) and perception about the technology (whether new technology is risky) and a disturbance term e_k with zero mean.

$$U_{ki} = X_i \alpha_k + e_{ki}, k = 1, 2; i = 1, \dots, n \quad (7.1)$$

Farmers are assumed to adopt a technology from which they derive the maximum utility. The i^{th} farmer will choose new technology if $U_{2i} > U_{1i}$ and the latent variable Z_i indexes the adoption decision.

$$z_i = \begin{cases} 1 & \text{if } U_{1i} < U_{2i} \text{ (Adoption)} \\ 0 & \text{if } U_{1i} \geq U_{2i} \text{ (Non adoption)} \end{cases} \quad (7.2)$$

The probability that z_i is equal to one i.e., the farmer adopts a new technology is a function of farm, farmer, and physical environment and perception specific independent variables:

$$\begin{aligned} P_i &= P_r(z_i = 1) = P_r(U_{1i} < U_{2i}) \\ &= P_r(X_i \alpha_1 + e_{1i} < X_i \alpha_2 + e_{2i}) \\ &= P_r[e_{1i} - e_{2i} < X_i(\alpha_2 - \alpha_1)] \\ &= P_r(U_i < X_i \beta) \\ &= F(X_i \beta) \end{aligned} \quad (7.3)$$

$P_r(\cdot)$ is a probability function; X is the vector of explanatory variables ($n \times k$ matrix) and β is a $k \times 1$ vector of parameters to be estimated. U_i is a random disturbance term, and $F(X_i \beta)$ is a cumulative distribution function for U_i evaluated at $X_i \beta$. Thus the probability that the i^{th} farmers adopt the new technology is based upon the greater utility derived from the same vis-à-vis the utility derived from the old technology; and the probability that a farmer adopts AI technology is a function of the vector of observed independent variables and the unknown parameters and disturbance term. The exact distribution of F is determined by U_i . If U_i is normal, then F has a cumulative normal distribution (Rahm and Huffman, 1984; Mazvimavi and Twomlow, 2009). The functional form of F is specified by a Double-Hurdle model, where U_i is an independent and normally distributed error term with zero mean and constant variance σ^2 .

7.1.2. The Empirical Model

When the dependent variable is binary, normal density function (Probit) or logistic function (Logit) is used to see factors that drive the adoption decision. In order to identify the factors that drive the adoption and extent of adoption Tobit model is frequently used following

Tobin (1958) under the assumption that the two decisions (adoption and extent of adoption) are affected jointly by the same set of factors. Thus Tobit model is appropriate when the adoption and extent of adoption is affected by same set of factors and the same is estimated through right or left censoring of the dependent variable (Green, 2007). Some previous research undertook this as norm to identify factors responsible for extent of adoption (Kaaya et al., 2005, Mazvimavi and Twomlow, 2009). However, in corner solution application, an important limitation of the standard Tobit model is the reliance on single mechanism that determines adoption and extent of adoption decision (Cragg, 1971; Wooldridge, 2010; Burke, 2010). Given this limitation of the Tobit model, a **Double-Hurdle or Two-Tiered model** is proposed originally by Cragg (1971) and later implemented by several technology adoption studies (Tefera et al., 2014; Hazarika et al., 2016; Beshir, 2014; Beshir et al., 2012; Gebremedhin and Swinton, 2003). The basic assumption in the double hurdle model is that the decision to adopt precedes the decision to extent of adoption and the factors that may affect the two decisions are likely to be different (Gebremedhin and Swinton, 2003; Tefera et al., 2014), since resource endowments, constraints, perception on risk and other socio-economic factors tend to be heterogeneous across individuals (Hazarika et al., 2016). In the present study double hurdle model is considered more appropriate in which a Probit regression on adoption decision (using all observation) is followed by truncated regression on the non-zero observations (Cragg, 1971).

The Double-Hurdle model is parametric generalization of the Tobit model, where two different stochastic processes explain the decision to adopt and the intensity of adoption of the technology (Green, 2007; Gebremedhin and Swinton, 2003; Tefera et al., 2014). The model is applied in such a way that both hurdles (decision to adopt and extent of adoption) have equations associated with them, incorporating the impact of various farm, farmer and physical environment characteristics. The explanatory variables appearing in both the equations may be different or may appear in either one of them. However, a variable appearing in both the equations may have contradictory effects in the two equations (Moffat, 2005). The double-hurdle model allows for the possibility that the two decisions are affected by the different set of variables with a varied level of impact.

As explained earlier, in the present study Cragg (1971)'s Double-Hurdle model is used to identify factors influencing the probability of adoption and intensity of use of AI technology. The two decision process is conditioned by the various explanatory factors mentioned in section 5.2. The double-hurdle model has an adoption (D) decision with an equation:

$$\begin{aligned} D_i &= 1 \dots \text{if} \dots D_i^* > 0 \dots \text{and} \\ D_i &= 0 \dots \text{if} \dots D_i^* \leq 0 \\ D_i^* &= \alpha'Z_i + \varepsilon_i \end{aligned} \quad (7.4)$$

Where D_i^* is a latent variable that takes the value 1 if the farmer adopts AI technology and 0 otherwise, Z_i is a vector of household characteristics and α is vector of parameters. ε_i refers to standard error term. The second hurdle of the Double-Hurdle model involves truncated model which considers all the non-zero (positive) observations of the first hurdle as observations in the dependent variable. The truncated model, which closely resembles the Tobit model, is expressed as:

$$\begin{aligned} Y_i &= D_i^* \text{ if } Y_i^* > 0 \text{ and } D_i^* > 0 \\ Y_i &= 0 \text{ otherwise} \\ Y_i^* &= \beta'x_i + v_i \end{aligned} \quad (7.5)$$

Where, Y_i^* is the observed response on the proportion of cattle born using AI technology, x_i is vector of explanatory factors, β is a vector of parameter and v_i is the standard error term.

The error terms are distributed as:

$$\begin{cases} \varepsilon_i \sim N(0,1) \\ v_i \sim N(0, \sigma^2) \end{cases} \quad (7.6)$$

The error terms ε_i and v_i are usually assumed to be independently and normally distributed. It is assumed that for each respondent the decision whether to adopt the technology and the decision on what proportion to adopt are made independently.

And finally the observed variable in a Double-Hurdle model is:

$$Y_i = D_i * Y_i^* \quad (7.7)$$

The log likelihood function for the Double-Hurdle model is

$$\text{Log}L = \sum_0 \ln \left[1 - \Phi \alpha z_i \left(\frac{\beta X_i'}{\sigma} \right) \right] + \sum_+ \ln \left[\Phi \alpha z_i \frac{1}{\sigma} \phi \left(\frac{Y_i - \beta X_i'}{\sigma} \right) \right] \quad (7.8)$$

Under the assumption of independency between the error terms ε_i and v_i the Double-Hurdle model is equivalent to univariate Probit model (equation 7.4) and the truncated regression model (equation 7.5). The “ Φ ” denotes the standard normal CDF (Univariate or multivariate) and “ ϕ ” is the univariate standard normal PDF.

Whether a Tobit model or Double-Hurdle model is appropriate for a given set of data on dependent and independent variables, can be determined by running the Probit, Tobit and the Truncated regression model separately and then by conducting a likelihood ratio test that compares the Tobit with the sum of the log likelihood functions of the Probit and Truncated regression models (Greene, 2007). This test has been carried out by several researchers to identify the appropriateness of the Tobit versus Double-Hurdle model (Gabremedhin and Swinton, 2003; Moffat, 2005; Tefera et al., 2014; Beshir, 2014; Hazarika et al., 2016) and the test results indicated the superiority of Double-Hurdle model over Tobit model. In the present study also the likelihood ratio test is carried out between Tobit and the Double-Hurdle model to find out the appropriateness of the model. The likelihood ratio statistic is computed using the following formula

$$\Gamma = -2[\ln L_t - (\ln L_p + \ln L_{TR})] \sim \chi_k^2 \quad (7.9)$$

Where L_t is the likelihood for the Tobit model; L_p is the likelihood for the Probit model; L_{TR} refers to likelihood for the Truncated regression model and κ is the number of independent variables in both the equations.

The test hypothesis is written as:

$$H_0: \lambda = \frac{\beta}{\sigma} \text{ and } H_1: \lambda \neq \frac{\beta}{\sigma}$$

H_0 will be rejected on a pre-specified significance level, if $\Gamma > \chi_k^2$

7.2. Measurement and Definitions of Variables for Adoption and Intensity of Adoption of AI Technology

Adoption literature identifies various factors which are hypothesized to have a combined influence on whether to adopt AI technology or not and to what extent it is adopted. These factors may include household characteristics (age, education of the household head, family size, land size, land allotted for fodder cultivation), socio economic characteristics (access to credit, membership of dairy cooperative society, whether beneficiary of any govt. dairy development programme, years of starting the dairy farm, herd size, number of years since first new about the technology) and the physical environment at which farmers operate (distance to market, distance to all weather road, access to grazing land, distance to AI centre, easy access to local breeding bull in the locality). The model has also incorporated a

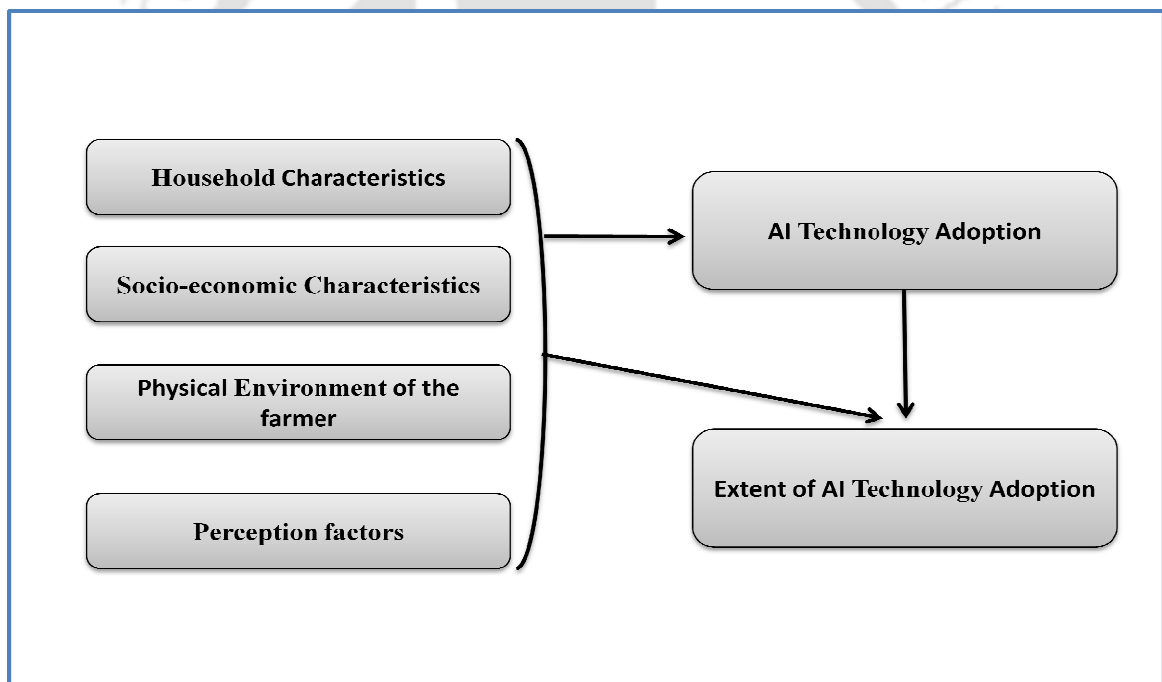


Figure: 7.1 Conceptual Model of Adoption and Extent of Adoption of AI Technology

perception factor (farmer's self-assessment regarding riskiness of the AI technology) to see if that has an influence on uptake of AI technology. These explanatory variables have been identified in the context of Assam following various technology adoption literatures (Doss, 2006; Feder et al., 1985; Feder and Umali 1993; Kaaya et al., 2005; Tefera et al., 2014; Rehman et al., 2007; Awotide et al., 2014; Beshir et al. 2012). Based on literatures

conceptual framework is presented in Figure 7.1 to segregate the factors affecting adoption and extent of adoption of AI technology

The theoretical justification for inclusion of the above variables along with their description and hypothesized relationship with adoption and extent of adoption of AI technology has been discussed below.

Age of the household head

Age of the farm household head is an important factor that may positively or negatively affect adoption of a technology. Older farmers gain knowledge through experience in entrepreneurial activity (Hazarika et al., 2016; Beshir, 2014), have more contacts with extension agent, better preferred by credit institutions and grows to be a less risk averse (Langyituo and Mekuria, 2005). However this may be encountered by young farmers being innovative (Adesina and Baidu-Forson, 1995; Doss, 2006). Thus, both adoption and extent of adoption of AI technology can increase (or decrease) with increase in the age of household head.

Education of the household head

Educated farm household head, who is assumed to be the major decision maker in farming related issues, may easily understand the benefit of adopting a new technology compared to a less educated farm household head. He/she may have exposure to better access to and acquisition of new technology related information and knowledge. Hence, education is hypothesized to have a positive relation with adoption of AI technology among the cattle rearing farm households.

Family Size

Household size has been considered as a proxy to family labor supply. Households with relatively larger family size may be beneficial in replacing the monetary cost incurred on hired labour when there is a shift from traditional technology to a labour intensive modern technology such as dairying with crossbred cattle. This is due to the fact that high yielding crossbred cattle reared in stall fed condition require a higher person days compared to

indigenous cattle reared with open grazing (Mwamuye et al., 2013). Thus, there remains a positive expected relation between family size and AI technology adoption.

Agricultural land holding

In a rural setting, land ownership of farming household is an important indicator of wealth position. Thus land holding is expected to affect technology use for a number of reasons including that wealthier households have greater access to resources and are better able to assume risk. Amount of land owned by the household also reflects the social status and prestige of the farm household, and the ability of a farmer to obtain credit (Doss, 2006). Thus, having a positive hypothesized relation between land holding by the household and AI technology adoption and use intensity, land size can be an important variable in the model.

Land for fodder cultivation

Input supply at domestic level may encourage adopting a new technology which is of high input-high output nature. Farmers practising fodder cultivation by allotting land for it from the total operational holding may tend to reduce the input cost and subsequently exploit higher gains of the improved technology. Thus, farm households which are able to devote larger amount of land for fodder cultivation may adopt AI technology and also may increase the extent of adoption compared to households which does not have such practice or have practice at a low extent.

Access to credit

Most of the empirical studies on technology adoption (Adesina and Zinnah, 1993; Bhalla, 1979; Hardiker et al., 1997; Islam et al., 2015) incorporate credit as one explanatory variable to identify whether access to the same helps as a driver of agricultural technology adoption. Access to credit facility helps in the adoption of new technology by mitigating liquidity constraint and improving risk taking capacity of the household. The expected sign of the relation between credit access and AI technology adoption is positive. The effect of the variable is captured as a dummy which takes the value “1” if the farm household has accessed credit and “0” otherwise.

Membership of DCS

Being in a farmer's group helps in rapid dissemination of knowledge and information about a new technology through a better social network and that gives an impetus to a non adopting farmer to adopt the technology (Ramirez, 2013). According to Sauer and Zilberman (2010), Spreading adoption related information through relevant peer groups can induce faster technology diffusion. The hypothesized relation between membership of dairy cooperative society and AI technology adoption is, hence, positive. The probable impact of this variable can be captured as a dummy assigning the value "1" if the farmer is a member of DCS, "0" otherwise.

Distance to market

Market is an important source for buying inputs such as fodder (green and dry) and concentrates along with being an important source for selling output (milk and milk products) produced in the farm. Farm households which have relatively higher distance to the nearest market may increase the transaction costs and thus reduces the profit margin. Again, market is an important place for a farmer to have an access to information about a new technology. Moreover, lesser distance to nearest market may help in reducing marketing risk which is particularly relevant for milk which is bulky, perishable and sold daily (Baltenweck and Stall, 2000). Increased distance from farm households to the market may reduce the possibility to adopt a technology. Thus, there exists a negative hypothesized relation of AI technology adoption and distance to market.

Distance to all weather road

Distance to the nearest all weather road may reflect the remoteness of the farm households and may be negatively related with information access. As pointed out by Beshir (2014) that places where labour input is a major cost component in livestock production investment distance to the nearest all weather road can be a good proxy for differences in the opportunity cost of labour. Hence, a priory assumption is that there is a negative relation between distance to the nearest all weather road and adoption of AI technology.

Access to grazing land

Crossbred cattle that are reared under stall fed condition usually are less dependent on availability of grazing land against non-descript cattle that completely depend on open grazing. Farming households that intend to shift from rearing of indigenous breed (traditional technology) to high yielding crossbred cattle (modern technology) may gradually become unconcerned about availability of grazing land. In other words, farm households which have easy access to grazing land may stick to rearing of indigenous breed and thus unlikely to accept the AI technology. Hence, a priory assumption can be that there is a negative relation between easy availability of grazing land and adoption of AI technology. Value “1” has been assigned for farmers who have easy availability of grazing land and “0” otherwise.

Beneficiary of Govt. dairy development programme

Farm households that have ever benefitted from any govt. dairy development programme may get an incentive and support to adopt a new technology. According to Feder and Umali (2003), “in a situation when technology adoption is conditioned by constraints such as lack of credit, limited access to information and inputs and inadequate infrastructure, Government generally pursues two general strategies: information provision (e.g., extension programmes) and the provision of subsidies and support programmes (output, input and credit subsidies and the provision of complementary infrastructure)”. It has a positive hypothesized relation between farming households that have ever availed the benefit of any dairy development programme and adoption of AI technology. The effect of the variable is captured as a dummy which takes the value “1” if the farm household has ever availed any of the govt. support programmes related to dairy development in the state and “0” otherwise.

Years of starting the dairy farm

Households having older farms may earn better managerial skills through experience than the new farm owning households. Thus, farm households with higher management skills may likely to adopt and intensify a new technology. Mazvimavi and Twomlow (2009) took intensity of adoption of different components of the technology to regress on years of experience with conservation farming as explanatory factor. There may be a positive

expected relation between number of years since first established the dairy farm and adoption and extent of adoption of AI technology.

Distance to AI centre

Distance to AI centre is an important variable for adoption of AI technology. Longer distance to AI centre may affect the conception rate negatively when farmers getting their cattle inseminated in the nearest AI centre. As the cattle owner has to reach the AI centre carrying the cattle covering long distances the heat period of the cattle may be adversely affected. Thus, the service is constrained posing a negative relationship between distance to the nearest AI centre and adoption of AI technology (Reynolds et al., 1996)

Access to local breeding bull

Easy availability of local breeding bull in the locality of farming households may tend to discourage farmers to go for AI technology. This is due to the fact that the resource poor farmers being risk averse by nature are generally unlikely to adopt modern technology if low cost and easily available traditional technology can be found at the farmers' locality. Thus, there remains a negative hypothesized relationship between availability of local breeding bull and adoption and extent of adoption of AI technology. This variable is a dummy with "1" if the local breeding bull is easily available at farmer's locality, "0" otherwise.

Herd size

The number of cattle owned by the farming households plays an important role in the adoption of AI technology. The use of AI requires a higher level of management input in aspects like feeding, routine cattle/herd observation, and communication with inseminator/technician and thus appears that as herd size is increased, farmers' capacity to manage and pay for AI services are constrained (Wyne and Cranfield, 1995). Hence, there may be a negative expected sign between herd size of the farmer and adoption of AI technology.

Number of years since first knew about AI

Longer the knowledge about a technology, larger is the possibility that the farmer may consider to adopt it. Risk-averse farmers immediately after knowing about a technology may not adopt unless he is confident about long term benefit from the adoption of new technology. Initiating early dissemination of information about a technology through awareness programme can be instrumental to draw interests towards the technology. Thus, there lies a positive hypothesized relation between the number of years since the head of household first heard about the technology and adoption and extent of adoption of AI technology.

Farmers self-assessing AI to be risky

Importance of attitudes in successful adoption of a technology, indicating the effective promotion of a new technology has to examine the beliefs of the respondents (Rehman et al., 2007; Sauer and Zilberman, 2010). According to Sunding and Zilberman (2001), the risk preferences of farmers are important in influencing the technology adoption decision. Thus, a subjective variable is incorporated to understand the effect of what the farmer perceives about the inherent riskiness of going for AI technology. The intuition is that poorer households that are unable to avoid consumption risk avoid this risk by opting lower return lower risk agriculture (Brick and Visser, 2015). Hence, farmers that consider AI technology as risky may not go for adopting it. The effect of this variable is captured as binary with “1” being that the farmer considers going for AI technology as risky and “0” otherwise.

The description of the variables used in the double hurdle model and their corresponding hypothesized relation of the coefficients are summarized in Table 7.1.

Table 7.1: Description of Variables and their Hypothesized Relation with Adoption of AI Technology

Factors	Description	Measure	Hypothesized relation
Dependent variable			
AI Adoption	Decision to Adopt AI or Not	1 for those who have gone for use of AI, 0 otherwise	
Proportion of cattle bred using AI	Number of calves born using AI out of total calves	Ratio	
Independent variable			
Age	Age of the household head in years	Years	+/-
Education	Number of years spent in school	years	+
family size	Number of family member living together	Number	+
Land size	Land owned by the household (in hectare)*	Number	+
Fodder cultivation	Land allotted by the farmer for fodder cultivation (in hectare)	Number	+
Access to credit	Access to formal or informal sources of credit	1 if farming household have access to credit, 0 otherwise	+
Membership of DCS	Farming household having membership to Dairy cooperative Society	1 if farming household have membership to DCS, 0 otherwise	+
Distance to market	Distance to the nearest market	Kilometer	-
Distance to all weather road	Distance to the nearest all weather road	Meter	-
Grazing land	Easy access to grazing land	1 if farming household has access to grazing land, 0 otherwise	-
Beneficiary of Govt. Dairy Development programme	Farming household has ever availed the benefit of any dairy development programme	1 if household is a beneficiary, 0 otherwise	+
Years of starting the dairy farm	Number of years since first established the dairy farm	Years	+
Distance to AI Centre	Distance to nearest AI centre	Kilometer	-
Access to local breeding bull	Easy availability of local breeding bull in the locality of the farming household	1 if farmer has access to local breeding bull, 0 otherwise	-
Herd size	Number of cattle owned by the farming household	Number	-
Number of years since first knew about AI	Number of years since the head of household first heard about AI	Years	+
Farmers self assessing AI as risky	Farmer's self assessment or perception in inherent riskiness of going for AI technology	1 if the household head considers AI to be risky, 0 otherwise	-

Notes: '+' and '-' indicates respectively the positive and negative hypothesized relationship of the independent variables with the dependent variables

7.3. Description of Explanatory Factors of Empirical Adoption Model

Table 7.2 presents the descriptive statistics of the continuous explanatory factors with mean difference test across adopters and non-adopters group of AI technology. It is evident that

among the continuous explanatory factors the mean education of the household head, land size owned by the household, land size allotted for fodder cultivation, distance to all weather road and number of years since first knew about AI are found to be statistically different between the two categories of respondents and significant at 1 Per cent probability level while the mean herd size is significantly different between the two groups at 5 Per cent probability level. The mean age of the household head of the adopter group is relatively higher compared to the non-adopter group but not significant. Mean years of schooling is more than 7 years for respondents adopting AI technology against 4.7 years for non-adopter group. The reason may be that during the survey carried out in the three districts of the state of Assam it is observed that respondents from the Nepali community engaged in the dairy activity had higher mean years of schooling and their proportion in the total sample size of the adopter group is 37 per cent (see Table 4.5 in chapter four). They are relatively dominant in Sonitpur and Karbi Anglong district. Education being crucial for technology adoption, a lower level of education limits the absorption of information and thus hampers the process of technology adoption-diffusion (Hazarika et al, 2016). Non-adopters have relatively higher family size compared to the adopter category but the difference between the two categories is not significant. The mean land size owned by the adopter group is higher by 0.067 hectare against the non-adopter group. Similarly, amount of land allotted by the AI technology adopting respondents for fodder cultivation is higher by 0.087 hectare compared to non adopting respondents. The mean distance to the nearest market from the non-adopter households is almost 4 kilometers while it is 2.9 kilometers for the adopters of AI technology. There is a notable difference observed in the mean distance to all-weather road from the respondent's house between the two categories. Other important factors among the continuous variables incorporated in the model that may exert significant causal relation in the adoption of AI technology are the herd size and awareness about AI. The mean herd size of the AI adopting respondents is 7 numbers of cattle heads against 5 numbers of non adopting respondents. A sizable difference is also observed with respect to number of years since first heard about AI where the mean period of knowing about AI for the adopter category is more than 13 years against close to 8 years for the non-adopters of AI. This indicates that the adopters have relatively better information access about AI and may also

be active participant in the awareness programme carried out by the concerned government departments.

Table 7.2: Descriptive Statistics of Explanatory Factors (continuous) by Farmer's Group in the AI Technology Adoption Model (mean)

Factors	Non-adopter (N=108)	Adopter (N=137)	Total (N=245)	t- test (two tailed)
Age	49.778 (1.167)	50.672 (1.101)	50.277 (0.801)	-0.5531
Education	4.676 (0.413)	7.489 (0.404)	6.249 (0.303)	-4.8128***
family size	6.083 (0.263)	5.723 (0.203)	5.882 (0.162)	1.103
Land size	0.1277 (0.060)	0.1943 (0.117)	0.1649 (0.072)	-3.4955***
Fodder cultivation	0.0117 (0.031)	0.0985 (0.114)	0.0603 (0.068)	-4.9361***
Distance to market	4.0648 (0.911)	2.8525 (0.137)	3.3869 (0.409)	1.4735
Distance to all weather road	471.7685 (35.902)	350.0007 (33.283)	403.678 (24.686)	2.4745***
Years of starting the dairy farm	27.083 (1.411)	27.5401 (1.274)	27.3387 (0.944)	0.2398
Distance to AI Centre	2.3865 (0.130)	2.5080 (0.117)	2.454 (0.087)	-0.6942
Herd size	5.3889 (0.358)	7.16058 (0.736)	6.379 (0.444)	-1.994**
Number of years since first knew about AI	7.852 (0.570)	13.459 (0.747)	10.988 (0.518)	-5.7084***

Source: Authors' estimation based on field survey data

Significant * at 10%, ** at 5% and *** at 1% probability level

Table 7.3: Distribution of Sample Households by Explanatory Variables (categorical)

Factors	Character	Non-adopter (N=108)	Adopter (N=137)	Total (N=245)	Pearson chi ² value
Access to credit	No	96	108	204	4.383**
	Yes	12	29	41	
Membership of DCS	No	96	74	170	34.5789***
	Yes	12	63	75	
Grazing land	No	67	94	161	1.1592
	Yes	41	43	84	
Beneficiary of Govt. Dairy Development programme	No	106	2	198	37.422***
	Yes	92	45	47	
Access to local breeding bull	No	2	106	35	24.3852***
	Yes	33	104	210	
Farmers self-assessing AI as risky	No	39	108	147	45.925***
	Yes	69	29	98	

Source: Author's estimation based on field survey data;

Notes: Significant * at 10%, ** at 5% and *** at 1% probability level

Among the dummy explanatory factors incorporated in the model statistically significant differences in the two categories of respondents is observed for all the variables except grazing land (see Table 7.3).

7.4. Econometric Results for AI Technology Adoption

7.4.1. Model Specification

The results of the likelihood ratio test between the Tobit and the two step modeling (using Probit and Truncated Regression) show that the Double-Hurdle model is superior over Tobit model since the $\Gamma=237.42$ which exceeds the critical χ^2 value with 17 degree of freedom [$\chi^2(17)=34.41$] and significant at 1 Per cent probability level. For the robustness of model specification, Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) are included as model selection criterion (see Appendix A7.1). Model with lowest AIC and BIC is always preferred. This also indicates a better fit of the Double-Hurdle model over Tobit model and suggests that decision to adopt AI technology and to what extent it is to be adopted are governed by two independent processes. Some other studies (Hazarika et al., 2016; Tefera et al., 2014; Beshir et al., 2012) have adopted these criteria of model specification between the Tobit and the Double-Hurdle model.

Table 7.4: Test Statistics of Double-Hurdle Model

Type of statistics	Probit, D	Truncated, Y(Y>0)
Wald χ^2	97.76	62.95
Prob> χ^2	0.000***	0.000***
LOG-L	-80.90	35.31
AIC	197.80	-32.61
BIC	260.825	22.87
χ^2 -Test Double Hurdle versus Tobit	$\hat{\Gamma}=237.42 > \chi^2(17)=34.41$	

7.4.2. Diagnostic Tests

While using the Double-Hurdle model for estimating the probability of adoption and extent of adoption of AI technology, explanatory variables are checked for problems of multicollinearity, endogeneity and heteroscedasticity. Following Gujarati (1995) and Beshir et al. (2012) the problem of multicollinearity for continuous variables is checked using the technique of Variance Inflation Factor (VIF) and Tolerance Level (TOL) where each

continuous explanatory variable is regressed on all the other continuous explanatory variables. The larger is the value of VIF of a variable, more it is said to be collinear. As a rule of thumb, VIF of a variable exceeding 10 and R^2 of the model is more than 0.90 the variable has severe multicollinearity problem. There are literatures which even suggest that the VIF of a variable should not exceed more than 5 or else the variable is said to be collinear. However, in the present study, there is not any problem of multicollinearity as the VIF value for all the continuous explanatory variables is less than 2 (mean VIF is 1.21) (see Table 7.5)

Table 7.5: Variance Inflation Factor (VIF) of the Continuous Explanatory Variables

Variables	Collinearity Statistics	
	VIF	Tolerance
Age	1.52	0.66
Education	1.14	0.87
family size	1.14	0.88
Land size	1.16	0.86
Fodder cultivation	1.13	0.89
Distance to market	1.05	0.95
Distance to all weather road	1.04	0.96
Years of starting the dairy farm	1.64	0.61
Distance to AI Centre	1.06	0.94
Herd size	1.14	0.88
Number of years since first knew about AI	1.24	0.81

To check the degree of association among the categorical explanatory variables contingency coefficients are computed (Table 7.6). Contingency coefficient is a χ^2 based measure of association and the rule of thumb is that a value of 0.75 or above indicates a stronger relationship between dummy explanatory variables (Healy, 1984; Beshir et al., 2012). This is also checked for the dummy variables included in the Double-Hurdle model and all the values are found to be less than 0.32. For endogeneity test, there is no such explanatory variable that is expected to be endogenous in the model and thus there is no need to conduct this test. In order to avoid problem of heteroscedasticity, robust standard error is estimated.

Table 7.6: Contingency Coefficients of Dummy Explanatory Variables

Factors	Access to credit	Membership of DCS	Grazing land	Beneficiary of Govt. Dairy Development programme	Access to local breeding bull	Farmer's self assessment of riskiness of going for AI
Access to credit	1	0.2005	-0.0704	0.2166	-0.1295	-0.0536
Membership of DCS		1	-0.0133	0.3188	-0.2097	-0.2531
Access to grazing land			1	-0.0623	-0.0737	0.0948
Beneficiary of Govt. Dairy Development programme				1	-0.0699	-0.1379
Access to local breeding bull					1	0.0952
Farmers self assessing AI as risky						1

7.4.3. Factors Influencing Adoption and Extent of Adoption of AI Technology

As the adoption and intensity of Adoption of AI technology is a two-step decision process and explanatory factors affect both the decisions at varying degree, the marginal effects are used for interpretation purpose of the variables. As presented in Table 7.7, both the first and second hurdle of the Double-Hurdle model are statistically significant ($p=0.000$) with Wald χ^2 value of 97.76 and 62.95 respectively indicating a good fit of the model.

The results of the Probit regression model show (Table 7.7) that the sample farmers in Assam are influenced significantly towards AI technology adoption by the education of household head, amount of land allotted for fodder cultivation, distance to nearest market, distance to all weather road, availability of grazing land, influence of govt. dairy development programme, years of starting the dairy farm, distance to the nearest AI centre, availability of local breeding bull at farmer's locality, herd size, number of years since first heard about AI and farmer's perception of riskiness about AI. However, the present study fails to provide evidence for significant influences of few other explanatory variables such as age of the household head, family size, land size owned by the household, access to credit and membership of DCS. The results of the truncated regression model show that access to credit, years of starting the dairy farm, availability of local breeding bull at farmer's locality, herd size, number of years since first heard about AI and farmers self assessing AI to be risky significantly influence the extent of adoption of AI technology (Table 7.7).

Education of the household head positively and significantly (at 1 Per cent probability level) affects adoption of AI technology, i.e., with one year increase in schooling leads to increase

in the probability of adoption of AI technology by 1.94 per cent. But to what extent the technology will be adopted is not significantly explained by the formal years of schooling of the head of household in the present study. The reason may be that educated farmers may immediately think of deciding to adopt a technology for their capacity to think on the perceived benefit of a new technology. But once adopted the education level of head of the household plays no role on deciding how much to accept of the new technology. The finding is consistent with the findings in the previous literatures (Ghimire et al., 2014; Asfaw et al., 2012; Kassie et al., 2011; Abdulai and Huffman, 2005), but contradicts the findings of Beshir et al. (2012) and Beshir (2014) where it is found that education is negatively related with the extent of adoption of improved forage technology in Ethiopia.

Fodder cultivation has a positive and statistically significant effect on adoption of the AI technology by the farming households. One extra hectare of land brought under fodder cultivation may increase 47.10 per cent chance of AI technology adoption by the dairy farm households. As mentioned earlier, domestic supply of inputs facilitates acceptance of a new technology. The reason may be that their expected profit will be higher due to lower input cost. However, the same does not exert significant effect on the extent of adoption of AI technology. Farmers after adopting a technology may gradually become commercialized and may become indifferent to whether they have their own input supply or not.

In accordance with the findings of many previous studies on agricultural technology adoption, the present study has also found access to credit as important determinant in the intensification of AI technology. As explained already the importance of credit on the households seeking to adopt new technology, credit access can play a bigger role in the extent of adoption of AI technology in Assam. There is a positive and significant relation witnessed in the extent of adoption of AI technology and access to credit. The study shows that there is 8.4 per cent increase in the probability of AI technology intensification for the farmers having access to credit facility. The finding is consistent with Islam et al (2015) and Lapple et al. (2015).

Distance to market has negative and significant influence in the adoption of AI technology. Farm households that are away from the market are constrained by higher transaction cost and information access about a new technology and thus have lower adoption rate. The

present study has found that 1 kilometer increase in the distance from farm house to the nearest market results to 10.98 per cent decrease in the probability of AI technology adoption. However, there is no significant influence of the same on extent of adoption of AI technology. The reason may be that those who have already adopted the technology and are in the process of intensification may have attained efficiency and are gradually less concerned about the transaction costs and information access. The finding is consistent with the finding in some other studies (Hazarika et al., 2016; Abdulai and Huffman, 2005).

The effect of distance to all-weather road is negatively related with AI adoption decision and significant at 10 per cent probability level. Higher the distance to the nearest all weather road the opportunity cost of labour increases and thus adoption decision of AI technology is negatively affected. But, the influence of the distance to all weather roads on extent of adoption is not significant. The possible explanation can be that as farmers go for intensification of the AI technology to increase the number of crossbred cattle they may ensure higher earnings of the family labourers by working in their own farm rather than seeking alternative options.

The present study hypothesized that the availability of grazing land negatively affects the adoption and intensity of adoption of AI technology. The reason may be that rearing of indigenous breed is dependent on open grazing against the crossbred cattle that are reared under stall feeding condition. Those farmers who find grazing land easily in the locality, their input cost will decline and they may find rearing indigenous breed economical and hence may unlikely to adopt AI technology. The finding counters this hypothesis and a significant positive relationship is observed in the adoption of AI technology and availability of grazing land. It is found that farmers having easy access to grazing land are 1.58 per cent more likely to adopt AI technology. One justification that can be put forth is that farmers are initially indifferent about the input cost and may decide to try the technology. However, there is a negative though not significant relation observed between availability of grazing land and extent of AI technology adoption. Gradual reliance on stall fed rearing of crossbred cattle make them indifferent to availability of grazing land nearby.

Farmers having older farms are generally more likely to adopt the AI technology. The reason may be that older farms are associated with better working experience as a source of

informal learning (Hazarika et al., 2016; Mazvimavi and Twomlow, 2009). However, the present study finds that farmers with a new farm are more likely to adopt the AI technology compared to the farmers having older farm. Similar significant and negative relation is witnessed between the extent of adoption of AI technology and number of years since the farmer started the farm. With one additional year older dairy farm may have the probability of decrease in the adoption and extent of adoption by 0.6 per cent and 0.02 per cent respectively. The justification in support of the finding may be that farmers starting with a new farm may be aspiring to increase the profitability through adopting more innovative technology. It may also be the case that the older farmers being risk averse may always stick to the traditional technology and may not want change. A new enterprise started by a new entrepreneur may have the intent to generate higher income and thus may be less risk averse. There can be direct effect on adoption of a technology when distance from the source of the necessary equipments/inputs and technicians required for performance of AI technology is concerned. Adoption rate will increase when the distance is less and vice versa. However, finding of the present study goes against the negative hypothesized relation between distance to AI centre and adoption of AI technology. It has been found that one kilometer increase in the distance to AI centre from farmer's house leads to 11.6 per cent increase in the probability of adoption of AI technology by the farm households. The justification in support of the positive relation may be that during the survey it was found that only 10.22 per cent of the farm households had inseminated their cattle at AI centre. The inseminator uses two wheelers to visit the farming households and he feels always profitable to inseminate farms located at distant places from AI centre. He can charge much higher fees than the usual rate in the name of higher fuel requirements of his vehicle and thus extra income allures him to service AI more to farms with longer distance from AI centre. Similar positive but non-significant relation is witnessed between distance to AI centre and extent of adoption of AI technology.

It is found in the study that increase in herd size significantly and positively affects adoption of AI technology at 1 per cent probability level.¹ However, increase in herd size significantly lowers intensity of AI technology adoption. One cattle head increase in the herd size increases 2.5 per cent increase in the probability of adoption and 1.26 per cent decrease in the probability of extent of adoption of AI technology. This implies that increase

in the number of cattle heads to a certain extent may embolden farmer to accept more innovative AI technology because he is gaining confidence to rear high yielding crossbred cows. However, it may happen that with further increase in the herd size with more crossbred cattle his capacity in cattle herd management and individual monitoring of stages of heat of individual cows are constrained and AI adoption intensity may decline.

Table 7.7: Double-Hurdle Estimates of Variables Influencing Adoption and Intensity of Adoption of AI Technology

Factors	Probit, D			Truncated regression, Y(Y>0)		
	Coefficient	Robust Std. Err.	Marginal Effect	Coefficient	Robust Std. Err.	Marginal Effect
Age	0.1179	0.109	0.0036	0.0024	0.0015	0.00235
Education	0.632***	0.24287	0.0194	0.0065	0.0040	0.00653
family size	-0.119	0.0441	-0.0037	0.0064	0.0059	0.00642
Land size	0.2654	0.172	0.0813	0.0127	0.0098	0.0127
Fodder cultivation	1.5384***	0.4208	0.4710	0.0095	0.0107	0.00955
Access to credit	0.1519	0.345	0.0465	0.084**	0.0384	0.0840
Membership of DCS	0.2037	0.2881	0.0624	0.0281	0.0366	0.0282
Distance to market	-0.359***	0.940	-0.1098	0.0006	0.0142	0.0006
Distance to all weather road	-0.0054*	0.0003	-0.00016	0.00003	0.0000	0.00003
Grazing land	0.5164*	0.2981	0.0158	-0.0161	0.0410	-0.0161
Beneficiary of Govt. Dairy Development programme	0.8062*	0.4773	0.0247	0.0374	0.0365	0.0374
Years of starting the dairy farm	-0.0222**	0.0105	-0.0068	-0.0022*	0.0013	-0.0022
Distance to AI Centre	0.37931***	0.1123	0.1161	0.0059	0.0150	0.0059
Access to local breeding bull	-1.759***	0.0274	-0.5385	-0.1547***	0.0339	-0.1547
Herd size	0.8246***	0.02741	0.0252	-0.0126***	0.0037	-0.0126
Number of years since first knew about AI	0.0714***	0.0204	0.2187	0.0064***	0.0020	0.0064
Farmer's self assessment of riskiness of going for AI	-0.0102***	0.7683	-0.2892	-0.0869*	0.0486	-0.0869
Constant	0.1021	0.7683		0.7604***	0.0969	
Test statistics						
	Wald χ^2 ***(17) = 97.76			Wald χ^2 ***(17) = 62.95		
	Log-L = -80.90			Log-L = 35.31		
	Pseudo R ² = 0.52					
	No of Observation = 245			No of Observation = 137		

Note: Significant * at 10%, ** at 5% and *** at 1% probability level

Number of years since first knew about AI is taken as proxy to access to extension support. The farmer who heard about AI much before has better extension contact compared to the one who has recently known about AI. The relation of this variable to the likelihood and extent of adoption is consistent with the hypothesized sign. There is significant (at 1 per cent probability level) increase in the adoption and extent of adoption of AI technology with

increasing number of years since first heard about AI. It is found that with one additional year increase in the period between first knowing about AI and adoption increases the probability of adoption and extent of adoption by 21.8 per cent and 0.6 per cent respectively. Thus, access to information about AI is very crucial for adoption decision of AI technology.

Perception on probable risk embedded in a new technology is very important determinant in the adoption literature. Farmers who feel new technology to be risky are very unlikely to adopt it. The finding of the study is in line with the hypothesized relation. There is significant (at 1 per cent probability level) decrease in the likelihood of adoption of AI technology when farmers self-assess a new technology to be risky. There is 28.92 per cent decrease in the probability of his/her adoption of AI when he/she feels adoption of AI to be risky. Corollary to this, there may be 8.69 per cent decrease in the probability of extent of adoption of AI when the farmer considers that adoption of AI technology is risky. Adequate information dissemination about the AI technology through deployment of sound technicians is very important so that there is reversal in the negative perception about AI and adoption rate is thus increased.

7.5. Constraints to Adoption of Crossbreeding Technology

As pointed out in chapter three that even though various efforts have been laid for diffusion of crossbreeding technology in an organized scale, the rate of adoption of the same is highly unimpressive. There may be various underlying constraints that farmers may perceive to hinder adoption of the technology. Ranking of the constraints according to their severity is, therefore, important so that policy prescription can be made to address them on priority basis so that rate of adoption of the technology can be enhanced in Assam. For this, constraints that farmers may perceive to negatively influence their adoption decision of crossbreeding technology are identified. Selection of the constraints in the present study is guided by previous empirical studies (Kumar et al., 2009a; Kumar et al., 2009b; Reddy et al., 2003; Rathore et al., 2009 b; Singh and Chauhan, 2006; Yadav et al., 2008 etc.) carried out in different parts of India along with certain constraints identified from comments made by farmers while carrying out the pilot study. To rank the constraints for adoption of crossbreeding technology 'Rank Based Quotient' (RBQ) technique has been employed. The probable constraints that farmers may be facing for crossbreeding technology adoption were

listed in the questionnaire during the pilot study. Farmers were asked about their perceived constraints as severe and were recorded and later they were reminded of the remaining listed constraints and asked for their preferred ranking. The criterion followed by the farmers was listed first and later they were asked to rank on the basis of individual priority by giving number 1 to 5. The strongly preferred criterion was ranked as 5, followed by 4 as less important and then 3 and so on. After interviewing the farmers, the constraint analysis was done to rank the preferences on the basis of RBQ. Analysis was done for the entire sample households of adopter (137) and non-adopter (108) for ranking the constraints.

RBQ as a problem identification technique is represented by the following mathematical notations:

$$RBQ = \sum_{j=1}^n \frac{f_i (n+1) * 100}{N * n}, \quad (7.10)$$

Where,

N = Total number of farmers

n = Total number of ranks (since there is five ranks, so n = 5)

i = Total rank for which RBQ is calculated (for a particular problem)

f = Number of farmers reporting the rank i (for the problem)

Table 7.8 to Table 7.12 presents the ranking of the constraints based on RBQ. While Table 7.8 presents the ranking of constraints for the overall constraints influencing crossbreeding technology adoption, Table 7.9 to Table 7.12 presents ranking according to various categories of constraints such as breeding, feeding, institutional and infrastructural services, and socio-psychological constraints. It has been found that among the various constraints farmers perceive to hinder their adoption of crossbreeding technology, the most severe constraint reported by the sample farmers is the high cost of fodder and concentrate followed by higher requirements of feed and fodder by crossbred cattle. The other constraints hindering adoption of crossbreeding technology in the order of severity are high overall cost of rearing crossbred cattle, higher requirement of care by crossbred cattle, getting green fodder is difficult etc. (see Table 7.8). The least severe constraints perceived by the sample farmers is the unavailability of regular milk market (consistent with the observation of ILRI (2007) in the context of Assam) followed by exposure to seasonal flood

hampers the rearing of crossbred cattle, favourable attitude towards growing grain and other crops than growing fodder crops, long calving interval of crossbreds etc (see Table 7.8).

Table 7.8: Adoption of Crossbreeding Technology and Farmer's Perception on Constraints to Dairying (N=245)

Sl. No.	Perceived Constraints	RBQ Score	Rank
1.	Poor conception rate i.e., poor results of AI	70.29	16
2.	Too much repeat breeding through AI	66.78	19
3.	Long calving interval	50.53	28
4.	Non availability of semen at AI centre	58.53	24
5.	Non Availability of Inseminator round the clock	51.35	27
6.	Lack of pregnancy diagnostic (PD) facility	64.24	20
7.	Lack of progeny tested bull	71.18	14
8.	Lack of AI centre in the vicinity	56.65	25
9.	Inadequate knowledge of AI	70.45	15
10.	High cost of AI	74.94	10
11.	Natural Service is favourable than AI	59.35	22
12.	Crossbreds require higher amount of feed and fodder	84.65	2
13.	Lack of knowledge on treatment of poor quality roughages	75.67	9
14.	Fodder and concentrate cost is much higher	85.14	1
15.	Lack of common grazing field	67.51	17
16.	Lack of knowledge on balanced feeding	76.49	8
17.	Getting green fodder is much difficult now a days	77.96	5
18.	Favourable attitude towards growing grain and other crops than growing fodder crops	50.53	29
19.	Lack of knowledge of recommended management practices	77.06	6
20.	Unavailability of veterinary facilities nearby	62.12	21
21.	Unavailability of regular milk market	38.45	31
22.	Poor extension support	73.63	12
23.	Lack of institutional credit facility	74.86	11
24.	Distant location of AI centre	58.61	23
25.	Crossbred cattle are susceptible to disease	76.82	7
26.	Crossbred cattle require comparatively more care in rearing	82.04	4
27.	Crossbred cattle cannot tolerate high temperature	66.94	18
28.	Overall cost of rearing crossbred cattle is very high	83.10	3
29.	AI results to more male calves	54.86	26
30.	It is uneconomical to rear crossbreds due to poor drought capacity of crossbred male	72.24	13
31.	Exposure to seasonal flood hampers the rearing of crossbred cattle	45.79	30

Source: Author's estimation based on field survey data

RBQ score and the ranking of the constraints related to breeding practices of crossbred cattle adoption is presented in Table 7.9. It indicates that among the eleven breeding constraints identified based on the previous studies and asking the sample farmers about the severity of

these constraints, it is found that high cost of AI is the most serious constraint the farmers face while trying to improve the genetic makeup of the indigenous cattle stock. This is followed by lack of progeny tested bull and poor conception rate of AI. These constraints however seem to be interrelated because poor conception rate is supplemented with high cost of AI leads to multiplication of their total costs incurred that affects negatively the farmers to go for AI. This is seen in the field that the inseminators charges the same rate for the repeated AI even though ideally the repeat charge has to be zero or lesser than the charge of the first service. According to Mugisha et al. (2014), there should not be any extra charge in repeats. Longer calving interval, non-availability of the inseminator round the clock, lack of AI centre in the vicinity etc. are the least important constraints affecting adoption of crossbreeding technology (see Table 7.9).

Table 7.9: Adoption of Crossbreeding Technology and Farmer's Perception on Constraints Related to Breeding Practices (N=245)

Sl. No.	Perceived Constraints	RBQ Score	Rank
1.	Poor conception rate i.e., poor results of AI	70.29	3
2.	Too much repeat breeding through AI	66.78	5
3.	Long calving interval	50.53	11
4.	Non availability of semen at AI centre	58.53	8
5.	Non Availability of Inseminator round the clock	51.35	10
6.	Lack of pregnancy diagnostic (PD) facility	64.24	6
7.	Lack of progeny tested bull	71.18	2
8.	Lack of AI centre in the vicinity	56.65	9
9.	Inadequate knowledge of AI	70.45	4
10.	High cost of AI	74.94	1
11.	Natural Service is favourable than AI	59.35	7

Source: Author's estimation based on field survey data

Table 7.10 presents constraints regarding feeding practices which may affect the adoption of crossbreeding technology. High cost of fodder and concentrate is the most serious constraint as perceived by the sample farmers followed by the farmer's perception that crossbreds require higher amount of feed and fodder. Table 7.10 shows that growing of fodder crops is equally important with growing of grain and other crops in the situation when farmer adopt crossbred technology. Their justification as emanated in the field is that growing of fodder crops will certainly address feed scarcity and enable them to partially substitute the high priced concentrate feed and encourage them to rear high yielding crossbred cattle. It has also

been observed in the field that most of the adopter farmers assign less importance on availability of common grazing land due to stall feeding nature of crossbred cattle and majority of the farmers have knowledge on treatment of poor quality roughages although they do not practise in the field condition. Their common apprehension is that fungus may affect it and become poisonous in a damp environment for the animal to eat.

Table 7.10: Adoption of Crossbreeding Technology and Farmer's Perception on Constraints Related to Feeding Practices (N=245)

Sl. No.	Perceived Constraints	RBQ Score	Rank
1.	Crossbreds require higher amount of feed and fodder	84.65	2
2.	Lack of knowledge on treatment of poor quality roughages	75.67	5
3.	Fodder and concentrate cost is much higher	85.14	1
4.	Lack of common grazing field	67.51	6
5.	Lack of knowledge on balanced feeding	76.49	4
6.	Getting green fodder is much difficult now a days	77.96	3
7.	Favourable attitude towards growing grain and other crops than growing fodder crops	50.53	7

Source: Author's estimation based on field survey data

Availability of various institutional and infrastructural services such as knowledge on recommended management practices, veterinary facilities, regular milk market, extension support, access to institutional credit and location of AI centre which may have bearing on adoption of crossbreeding technology is presented in Table 7.11. It is found that lack of knowledge of the farmers on recommended management practices is the serious constraint among the constraints relating to institutional and infrastructural services in adopting new

Table 7.11: Adoption of Crossbreeding Technology and Farmer's Perception on Constraints Related to Institutional and Infrastructural Services (N=245)

Sl. No.	Perceived Constraints	RBQ Score	Rank
1.	Lack of knowledge of recommended management practices	77.06	1
2.	Unavailability of veterinary facilities nearby	62.12	4
3.	Unavailability of regular milk market	38.45	6
4.	Poor extension support	73.63	3
5.	Lack of institutional credit facility	74.86	2
6.	Distant location of AI centre	58.61	5

Source: Author's estimation based on field survey data

dairy technology such as crossbreeding followed by lack of institutional credit facility. Table 7.11 also shows that unavailability of regular milk market is the least important constraint in

crossbreeding technology adoption followed by distant location of AI centre. This is consistent with the results of Double-Hurdle model which indicate that distance to AI centre affects positively the adoption of AI technology among the sample farmers (see Table 7.7).

Farmer's socio-psychological constraints to adoption of crossbreeding technology are reported in Table 7.12. It shows that among seven different socio-psychological constraints that were believed to affects adoption of crossbreeding technology adoption, farmer's perception on high cost of rearing crossbred cattle compared to the rearing of indigenous cattle is the dominant constraint affecting the adoption of crossbreeding technology. This is followed by farmer's perception on crossbred cattle requiring more care in rearing compared to indigenous cattle. Farmer's perception on exposure to seasonal flood hampers rearing of crossbred cattle is the least important socio-psychological constraint followed by AI results to more male calves as reported by the sample farmers in the study (see Table 7.12).

Table 7.12: Adoption of Crossbreeding Technology and Farmer's Perception on Socio-psychological Constraints (N=245)

Sl. No.	Perceived Constraints	RBQ Score	Rank
1.	Crossbred cattle are susceptible to disease	76.82	3
2.	Crossbred cattle require comparatively more care in rearing	82.04	2
3.	Crossbred cattle cannot tolerate high temperature	66.94	5
4.	Overall cost of rearing crossbred cattle is very high	83.10	1
5.	AI results to more male calves	54.86	6
6.	It is uneconomical to rear crossbreds due to poor drought capacity of crossbred male	72.24	4
7.	Exposure to seasonal flood hampers the rearing of crossbred cattle	45.79	7

Source: Author's estimation based on field survey data

7.6. Summing Up

The above discussion deals with identification of the factors that affect the probability of adoption and intensity of use of AI technology in Assam. Cross-section data are used to analyze the influence of farm, farmer, physical environment at which farmers operate and perception characteristics on the probability of adoption and extent of adoption of AI technology.

In the analysis of the chapter, the study has found education of the head of the household as positive and significant suggesting that it is a powerful factor explaining probability of adoption of AI technology. Amount of land allotted for fodder cultivation is also found to significantly and positively influence AI technology adoption. Also, there is a positive and significant relation between credit access and extent of AI technology adoption which calls for facilitating AI adopting farmers with better access to credit services. Physical environment characteristics in which farmers operate such as distance from farm household to market and all-weather road affect adoption of AI technology negatively implying that market linkages and expansion of rural roads can go a long way in increasing the rate of adoption of AI technology. The study has also found 'availability of grazing land' and 'beneficiary of existing dairy development programmes' as positive and significant factor for AI adoption. Relatively new farms are found to be influenced more towards adoption and extent of adoption of AI technology necessitating policy priorities on the part of the government for targeting these farms for diffusion of AI technology. It has been found that distance to AI centre is positive and significant implying that more than the spread of AI centre, deployment of technicians is important as AI services are mostly carried out at farmers' door step. Access to local breeding bull negatively influences both adoption and extent of adoption of AI which has the implication that risk-averse farmers finding local breeding bull easily at the locality may not adopt and intensify AI. Therefore, castration of local breeding bull may be carried out at a massive scale to diffuse the AI technology among the farmers. Farmers with bigger herd size are adopting AI technology more but further increase in the herd size is found to negatively affect the intensity of adoption of the technology. This may be attributed to the difficulty to pay for the larger number of services with a bigger herd size or due to declining conception rate resulting from the failure to individually monitor the stages of heat of the cattle. Number of years since knowing about AI is taken as a proxy to extension effort and awareness programme. In the above analysis, it has been found that farmers knowing about AI much before are more likely to adopt and increase the intensity of use of AI technology. This calls for strengthening the extension services of the government for making people aware about the AI technology. It is also found that the chances of adoption and extent of adoption reduced by 28.9% and 8.69% respectively for those farmers who consider AI technology to be risky. If this perception can

be reversed through better extension services and awareness programme, the rate of adoption and use intensity of AI are likely to increase in the state.

Various constraints those are likely to affect adoption of Artificial Insemination by the cattle farm household have been ranked according to their severity in the analysis above. The ranking is done by categorizing the constraints based on breeding, feeding, institutional and infrastructural services, and socio-psychological constraints and also across categories. Ranking of constraints across categories indicate that farmers rank the high cost of fodder and concentrate as severe followed by higher requirements of feed and fodder by crossbred cattle. Higher requirement of care by crossbred cattle, getting green fodder difficult etc. are the other constraints that are ranked in terms of its severity following the above two constraints. The constraints that farmers consider as the least important in affecting their adoption of crossbreeding technology are unavailability of regular milk market followed by exposure to seasonal flood and favourable attitude towards growing grain and other crops than growing fodder crops and long calving interval of crossbreds. According to various categories of constraints, high cost of AI, lack of progeny tested bull and poor conception rate of AI are the most severe breeding constraint affecting non-adoption of AI technology. Constraints related to feeding practices indicate that high cost of fodder and concentrate and higher requirement of feed and fodder by crossbreds is ranked as the most important feeding constraints affecting negatively the adoption of crossbred cattle. While the lack of knowledge of the farmers on recommended management practices and lack of institutional credit facility have the highest RBQ score indicating severe constraints relating to Institutional and infrastructural services in adopting new dairy technology, farmers' perception on crossbred cattle requiring more care in rearing envisage the highest RBQ score in the category of socio-psychological constraints.

Notes:

¹ The finding in the present study encounters the findings in Kaaya et al. (2005). However, a notable difference in the quality of the variable exists. The average number of cattle herd size in the present study was 5.39 cattle heads which is much lower than what Kaaya et al. (2005) found in their study in Uganda (14 cattle heads).

APPENDIX 7

Appendix A7.1: Double-Hurdle and Tobit Estimates of Variables Influencing Adoption and Intensity of Adoption of AI Technology.

Factors	Probit, D			Truncated regression, Y(Y>0)			Tobit		
	Coefficient	Robust Std. Err.	Marginal Effect	Coefficient	Robust Std. Err.	Marginal Effect	Coefficient	Robust Std. Err.	Marginal Effect
Age	0.1179	0.109	0.0036	0.0024	0.0015	0.00235	0.00227	0.00378	0.00113
Education	0.632***	0.24287	0.0194	0.0065	0.0040	0.00653	0.01962**	0.00818	0.00978
family size	-0.119	0.0441	-0.0037	0.0064	0.0059	0.00642	-0.0133	0.01615	-0.00664
Land size	0.2654	0.172	0.0813	0.0127	0.0098	0.0127	0.02924	0.02299	0.01458
Fodder cultivation	1.5384***	0.4208	0.4710	0.0095	0.0107	0.00955	0.05112	0.03391	0.02549
Access to credit	0.1519	0.345	0.0465	0.084**	0.0384	0.0840	0.04998	0.10035	0.02492
Membership of DCS	0.2037	0.2881	0.0624	0.0281	0.0366	0.0282	0.11146	0.08542	0.05558
Distance to market	-0.359***	0.940	-0.1098	0.0006	0.0142	0.0006	-0.0638**	0.02514	-0.03183
Distance to all weather road	-0.0054*	0.0003	-0.00016	0.00003	0.0000	0.00003	0.0166	0.00009	0.57907
Grazing land	0.5164*	0.2981	0.0158	-0.0161	0.0410	-0.0161	-0.0190	0.09278	-0.00949
Beneficiary of Govt. Dairy Development programme	0.8062*	0.4773	0.0247	0.0374	0.0365	0.0374	0.21939**	0.09195	0.109401
Years of starting the dairy farm	-0.0222**	0.0105	-0.0068	-0.0022*	0.0013	-0.0022	-0.0015	0.00323	-0.00074
Distance to AI Centre	0.37931***	0.1123	0.1161	0.0059	0.0150	0.0059	0.06695**	0.03316	0.03338
Access to local breeding bull	-1.759***	0.0274	-0.5385	-	0.0339	-0.1547	-	0.08553	-0.22428
Herd size	0.8246***	0.02741	0.0252	0.1547***	-	-	0.4498***	-	-
Number of years since first knew about AI	0.0714***	0.0204	0.2187	0.0126***	0.0037	-0.0126	0.0032	0.00369	0.00160
Farmer's self assessment of riskiness of going for AI	-0.0102***	0.7683	-0.2892	0.0064***	0.0020	0.0064	0.0193***	0.00453	0.00962
Constant	0.1021	0.7683	-	0.7604***	0.0969	-	0.4891***	0.08317	-0.24388
Test statistics									
	Wald χ^2 ***(17) = 97.76			Wald χ^2 ***(17) = 62.95			Log-L = -164.30		
	Log-L = -80.90			Log-L = 35.31			Pseudo R ² = 0.33		
	Pseudo R ² = 0.52			AIC = -32.61			AIC = 366.61		
	AIC = 197.80			BIC = 22.87			BIC = 433.13		
	BIC = 260.825			No. of Observation = 137			No. of Observation = 245		
	No. of Observation = 245								

Significant * at 10%, ** at 5% and *** at 1% probability level

CHAPTER EIGHT

SUMMARY OF FINDINGS, CONCLUSION AND POLICY SUGGESTIONS

The present study is motivated by the debate and discussion centering around the issues of impact of crossbreeding technology on cattle farmers, the factors determining adoption of crossbreeding technology and constraints impeding its adoption in Assam. These issues are mostly considered to be region specific. The present study may be considered as an effort to understand the issues of cattle crossbreeding in the state, where crossbreeding technology has a relatively much lesser penetration. Before drawing the final conclusion and elicit policy implications, it would be worthwhile to have a recap of the principal findings of the study. A brief summary of these findings is presented in the following section.

8.1. Principal Findings

8.1.1. Crossbreeding Technology Diffusion in Assam

- For the crossbreeding programme to function effectively breeding policy was revised and adopted in the state considering the climatic and infrastructural conditions of the locality. For the diffusion of AI Deep Frozen Semen Bank was established under Indo-Australian Cattle Breeding policy in March 1976 and later on strengthened under ARIASP. ALDA was created in 2004-05 as a state implementing agency for the smooth conduct of the AI activities in the state. Thus, AI network expanded to all veterinary establishments, existing FSBs are renovated and 4 more FSBs are also introduced. For enhancing distribution capacity, FSBs are equipped with liquid nitrogen (LN) silos, distribution vehicles, storage cyo cans and transport type cans. Emphasis was also given on ensuring quality of semen by starting newly a Frozen Semen Bull Station at Barapetta by inducting quality bulls from CCBF, Sunabeda, Orissa and Hessarghatta. Bangalore. Furthermore, training of AI workers on AI management, FS technology and quality control was conducted for efficient service delivery. In 1996-97, number of AI done in the state was only 17,000 which rose to 3,23,883 in 2013-14 with an annual

growth rate of 18.93 per cent during the period under consideration. Again, the number of calf born in the state during 1997-98 was 9,152 which rose to 1,13,360 with an annual growth rate of 17.03 per cent. At district level, Barpeta district has the highest number of AI done figure (60,063) followed by Kamrup District (49,566) with corresponding calf born figure of 17,762 and 16,874 respectively. The highly flood affected district of the state, Dhemaji has the lowest AI done figure (396) followed by Dima Hasao (447) during 2013-14.

8.1.2. Bovine Population and Milk Production Dynamics in Assam

- The bovine population in the state over the years is favoured for milk production as share of adult males has decline and adult females have increased. Similar pattern is envisaged in the composition of crossbred cattle population. Again, pattern of growth of crossbred cattle shows that although there has been massive efforts undertaken for improving the cattle stock of the state after formation of ALDA in 2004 and NPCBB taking the lead role in sponsoring cattle breed improvement programme in Assam, the annual growth rate of crossbred cattle during 2003-2012 has been very unimpressive. In addition to this, Assam has a very negligible share of crossbred cattle population compared to the other states. Some of the southern states such as Kerala (79 per cent) and Tamil Nadu (39 per cent) and states and UTs in the North like Punjab (69 per cent), Chandigarh (86 per cent), Delhi (63 per cent), Haryana (35 per cent) and Jammu and Kashmir (34 per cent) are performing relatively much better in the breed improvement programme.
- The crossbred cattle constituting a negligible proportion (3.84 per cent according to Livestock Census, 2012) in the total cattle population contributes a higher proportion in total cattle milk production (35.42%) in the state. This has been possible due to higher milk yield of crossbred cattle relative to the indigenous breed. Analyses of secondary data reveal that cattle crossbreeding has resulted 37% increase in total milk production in the state. A marked structural transformation in the composition of bovine milk in the state is also noticed during the period 1986-87 to 2006-07 indicating that with the passage of time productivity has played an important role in the growth of bovine milk production in the state.

8.1.3. Milk Productivity, Lactation and Reproduction Characteristics of Cattle and Input-Output Relation in Milk Production

- Among the sample farmers there is significant difference in milk productivity per lactation between crossbred and indigenous cattle breeds across size category farmers pointing out that crossbred cattle yields approximately 537 liters ($p < 0.01$) of more milk per lactation than the non-descript cattle.
- The age of first calving of crossbreds in the study sample is relatively much lower than the indigenous breeds. The age of first calving for crossbreds, on average, across size groups of farmers is 31 months compared to almost 46 months for indigenous cattle. This indicates that farmers with crossbreds have to wait relatively lesser time to get the first calf compared to the farmers with indigenous cattle having the implications on conservations of feed and fodder resources and economy in farm management activities.
- Differences between crossbred and indigenous cattle in terms of calving interval and lactation length explain that the calving interval is shorter for crossbred cattle compared to indigenous ones, while lactation length of crossbred cattle is relatively much longer than indigenous cattle. It is found in the sample farms that calving interval for the overall crossbred cattle is 427.71 days against 530.56 days of indigenous breed. With respect to lactation length, crossbreds give milk for an average period of 277.23 days compared to 233.06 days.
- Based on regressing various inputs on average milk productivity (employing OLS technique) it is found that concentrate is the most important input to significantly affect the productivity of crossbred and indigenous cattle followed by dry fodder. It is found that one per cent increase in the value of concentrate fed to the animals leads to 0.40 and 0.13% increase in the value of milk production per day per SAU of crossbred and indigenous cattle respectively.
- Dry fodder is important factor to significantly ($p < 0.01$) influence milk productivity. A one per cent increase in the value of dry fodder fed to the animal leads to 0.19 and 0.25% increase in the value of milk production for crossbred and indigenous cattle respectively.

- Imputed value of the labour hour spent for indigenous cattle influences positively and significantly the productivity of indigenous cattle. However the same is not found to be significant to influence productivity of crossbred cattle. The reason may be that the average herd size of standard milch animal unit of crossbreds is higher than the average herd size of the indigenous cattle (5.69 milch SAU of crossbreds compared to 2.65 of Indigenous breed). Hence, the labour hour spent per indigenous milch SAU on farming operations may be proportionately more compared to crossbreds in the model.
- Factor such as expenditures on medicine, doctor's fee, vitamin, calcium and minerals and cost incurred on AI/NS are found to affect the productivity of both crossbred and indigenous cattle significantly and positively.
- Linear OLS regression on input-output relation shows that irrespective of breeds, one per cent increase in feeding of green fodder, dry fodder and concentrate may lead to increase in the value of output in the magnitude of respectively 0.03, 0.25 and 0.31% per milch SAU/day.

8.1.4. Economics of Dairying and Determinants of Profitability in Dairying

- Returns from milk production by taking the imputed value of domestically available fodder resources, imputed cost of family labour, and imputed value of cow dung and on the income side the imputed value of domestically consumed milk indicates that net return from milk production for crossbred cattle adopter farmers is Rs. 37.02/day/milch SAU compared to Rs. 2.62 for non-adopters.
- According to farm size category, large farmers have higher net returns for both adopters (Rs. 50.28/day/milch SAU) and non-adopters (Rs. 14.32/day/milch SAU) group. It is estimated that for the average size of cattle holdings of adopters (5.69 milch SAU) the annual income is estimated as Rs. 76,884.99 against the income of Rs. 2534.20 for the non-adopters for the average size of cattle holding of 2.65 milch SAU.
- Based on actual value of operational cost and return from milk sale the net return from milk sale per standard animal per day is estimated at Rs. 61.60 for adopters and Rs. 19.22 for non-adopters. Thus, given the actual net return per standard animal per day of adopters and non-adopters, the annual income for the average farm size

households is estimated at Rs. 1,27,933.96 for adopters and Rs. 18,590.55 for non adopters.

- According to farm size category, small farmer adopters have net return of Rs. 69.62/day/milch SAU based on actual paid out cost and returns from milk sale which is higher than the average net return of overall adopters.
- Imputed value of family labour estimated at par with cost on hired labour brings the major difference in the net returns from dairying for the two different cases (with and without cost and return imputations). A large percentage of the sample farmers carried out dairying activities by engaging family labour which led to underestimation of operational costs.
- Variables that affect actual profitability (returns from milk sale minus the paid out cost) of dairying positively and significantly are landholding ($p < 0.05$), access to credit ($p < 0.10$), membership of DCS ($p < 0.10$), sale price of milk ($p < 0.01$), proportion of milk sold ($p < 0.01$), and actual value of feed and fodder fed to the animal ($p < 0.01$). The only variables that have statistically significant negative relation with the dependent variable is years of starting the dairy farm ($p < 0.10$).
- Variables such as herd size, contact with extension agent, off-farm income, price received for the milk sold and proportion of milk sold positively and significantly affects profitability from dairying (returns from milk produced minus the imputed value of domestically available inputs). Variable such as the imputed labour cost has significant expected relation with the dependent variable. The highly significant and negative relation of imputed labour cost with dependent variable implies that imputation of the family labour cost is the important determinant of the differences between the two models. The households that have higher family size also have higher adult equivalent to work in the dairy farm. Adjustment of the opportunity cost of the family labour through imputations may exert a negative effect on the profitability of milk production.

8.1.5. Crossbreeding of Cattle and Employment in Dairying

- The pattern of labour use in the sample farms indicates that the differences in the engagement of male and female workers in case of small farms across farm operations

are relatively much less (5.72 female person days/month in relation to 8.56 male person days/month) compared to large farms where labour use of male person days/month is three times more than the female person days.

- There are variations in the use of labour hour between male and female groups according to various operations of dairying. Operations like feeding and grass collection and cleaning of cattle sheds and washing of animals engages relatively more female labour than activities like marketing of milk.
- There is significantly higher use of labour per farm for adopter group over the non-adopter. It is found that adoption of crossbred cattle significantly leads to 13.97 more person days/month compared to non-adopter. The increase in labour use is the highest for large farms (19.65 person days/month) followed by medium category farms (11.88 person days/month).
- Labour use differences according to farm operations with adoption of new dairy technology, i.e., crossbred cattle indicates that operations like feeding and grass collection leads to statistically significant increase in the use of labour per farm across farm size categories (7.03 person days/month). Other farm operations such as milking and cleaning of cattle sheds and washing of animals also exhibits significant increase in the labour use for both farm-wise and milch SAU-wise.
- Adoption of crossbred cattle directly leads to significant increase of male and female labour use equivalent to 9.94 and 4.03 person days per month respectively. For the small and medium farms the increase in labour use after adoption of crossbred cattle is significant at 1% probability level (based on two tailed *t*-test) for both male and female workers. However, for large farms, the requirement of services is found to be significant for male labourers only.
- OLS (log linear) regression results of the factors affecting labour use in the sample dairy farms point out that adoption of crossbred cattle is found to be statistically significant at 1% probability level. It is seen that farm household with crossbred cattle have 24.77 per cent higher monthly labour use in the sample farms implying that crossbred cattle adoption has a much higher effect on employment generation.
- If it becomes possible to achieve national average of 20.81 per cent of crossbred cattle population by effectively implementing the crossbreeding programme in the state of

Assam then it may create 1,58,400.53 and 1,92,102.77 person days/month for small and medium farms respectively.

8.1.6. Milk Marketing, Market Accessibility and Determinants of Marketed Surplus

- Average milk production, sales and retention for self-consumption are directly related to farm size. This indicates that production, sales and household retention for self-consumption increases with the increase in farm size for both the adoption groups.
- It is found that almost 30% of the farm milk production for sample farmers of the non-adopter category is consumed domestically and the rest 70% is sold as marketed surplus. Adopters have higher absolute consumption and sales of milk per farm commensurate with increased production in relation to the sales and consumption of non-adopters.
- Adopters are commercially oriented to a higher extent in their milk production behaviour. Of the 137 sample farmers with adopters of crossbred cattle, 98.54% farmers are market participants that sell a part of their produce in market (or any other marketing agent) against 83.33% of the non-adopters (108 sample farmers).
- Among the marketing channels adopted by the sample farmers, cooperative and selling by self in the market together are the dominant sources of milk sale (almost 63%). This is followed by other channels such as, selling to private traders and retail sale in the neighborhood.
- Crossbred cattle adoption is highly significant (p value = 0.000) and likely to induce a 14.60 per cent higher marketed surplus. Other variables such as herd size, price received for the milk sold and membership of Dairy Cooperative Society (DCS) are positive and highly significant to influence increased marketed surplus.
- The existence of an inverse and significant (p -value < 0.10) relationship between distance to market and marketed surplus explains that higher the distance to market, lower is the marketed surplus of milk. The possible explanation for the inverse relationship can be that use of other marketing channels (such as private trader, cooperatives and retail selling in the farmer's neighbourhood) has stronger effect than selling directly in the market as more than 65% of the total produce is sold to cooperatives or picked up by professional vendor and buyers in the neighborhood.

- Price received on the sale of milk is found to be an important signal in the study location to positively influence marketed surplus of milk. The elasticity of marketed surplus of milk to its price is about 1.33, implying that an increase in the prices of milk by one rupee may likely to induce a 1.33 per cent larger marketed surplus.

8.1.7. Crossbred Cattle Adoption and Treatment Impact on Farmers' Wellbeing

- Different matching estimators such as five nearest neighbour matching, Epanechnikov kernel based matching with bandwidth 0.06 and radius matching with caliper 0.1 and implementing common support have been used to see treatment effects of crossbred cattle adoption on wellbeing of the farmers. The wellbeing of the farmers is measured in terms of the household income by different sources after adoption of crossbred cattle, per capita consumption of high value commodities, and employment of labour (increased labour use). The results broadly indicate positive effects on the farmers.
- The significant increase (p -value = 0.000) in net dairy income per annum after adoption of crossbred cattle ranges from Rs 44,573.03 to Rs 44,904.27 for the different matching estimators. Normalizing the net dairy income in terms of per milch cattle per day, the significant increase (p -value = 0.000) after adoption of crossbred cattle is estimated in the range of Rs 42.06 to Rs 42.21.
- Dairy income being the dominant component of farm households showing highly significant rise after adoption of high yielding crossbred cattle, the total household income also shows significant change (at 10% probability level) for adopters vis-à-vis the matched non-adopters of crossbred cattle. The total household income is found to increase in the range of Rs 46,299.54 to Rs 54,389.08 after adoption of crossbred cattle.
- The average treatment effects on the treated after adoption of high yielding crossbred cattle for average per capita daily consumption of high value food commodities indicate a positive and significant increase for consumption of milk and meat. Adopter households have higher average per capita daily consumption by a range of 105.87 to 109.55 grams of milk and milk products and 6.51 to 8.40 grams of meat consumption.
- The differences in average fish consumption between similar pairs of households belonging to different technological status (adopters and non-adopters of

crossbreeding) are positive but found to be statistically non-significant. Moreover, the changes in per capita daily consumption of vegetables and fruits are found to be positive for specific matching estimators only (KBM for vegetable consumption and NNM and KBM for fruit consumption)

- Adopters are found to have statistically significant increase in total labour use after high yielding crossbred cattle adoption equivalent to the range of 10.27 to 10.55 person days per month ($p=0.000$) in relation to the matched non-adopters. Of the changes in monthly total person days, significant rise in male and female person days is constituted in the range of 6.04 to 6.31 ($p=0.000$) and 4.22 to 4.34 person days per month ($p=0.000$) respectively.
- Heterogeneous treatment effects indicate that the increase in annual net dairy income for the adopter households are in the range of Rs 58320.20 to Rs 59508.54 for the large farms compared to its matched non-adopters against the small to average farms (with less than 6 cattle heads) with a range of Rs 39896.75 to Rs 40177.31.
- Educated households have significantly higher farm income in the range of Rs 62966.87 to Rs 78300.08 compared to its non-adopter counterpart. The higher net dairy income for the high educated adopter farms may be due to their ability to process the information on high yielding cattle rearing practices resulting to better farm management capacity.
- The overall labour absorption is higher by a small margin in case of large adopter farmers compared to its matched non-adopters (in the range of 11.55 to 12.05 person days/month) against the small to average farmers (10.01 to 10.26 person days/month).
- The increase in total labour absorption of adopters with higher than average education of the household head is much higher compared to matched non-adopters (in the range of 13.20 to 13.93 person days/month) against the matched comparisons of adoption groups with lesser than the average education of household head (9.74 to 10.41 person days/month).
- All the matching algorithms show statistically insignificant increase in per capita daily consumption of milk for farm households with higher than the average education level and larger than average farm size (except using RM).

- The propensity score matching result suggest that effect of dairy income and employment will be more in case of relatively larger farmers and farmers with higher than the average education level of household.
- Three propensity scores specifications for sensitivity checks by incorporating higher order variables such as squared term of age and education with the explanatory variables of the original propensity score specification and reduced probit model specification indicates that the results display stability to different propensity score specifications as the range of changes in the outcome variables do not vary noticeably in level of significance and magnitude between propensity scores specifications in the original and the alternatives.

8.1.8. Determinants of Crossbreeding Technology Adoption

- Education of the household head positively and significantly (at 1 per cent probability level) affects adoption of AI technology. With one year increase in schooling the probability of adoption of AI technology goes up by 1.94 per cent. But to what extent the technology will be adopted is not significantly explained by the formal years of schooling of the head of household in the present study.
- Fodder cultivation has a positive and statistically significant effect on adoption of AI technology by the farming households. One extra hectare of land brought under fodder cultivation may increase 47.10 per cent chance of AI technology adoption by the dairy farm households. As mentioned earlier, domestic supply of inputs facilitates acceptance of a new technology. The reason may be that their expected profit will be higher due to lower input cost.
- Access to credit is found to be an important determinant in the intensification of AI technology. The study shows that there is 8.4 per cent increase in the probability of AI technology intensification for the farmers having access to credit facility.
- Distance to market has negative and significant influence on the adoption of AI technology. Farm households that are away from the market are constrained by higher transaction cost and information access about a new technology and thus have lower adoption rate. The present study has found that 1 kilometer increase in the distance

from farm house to the nearest market results to 10.98 per cent decrease in the probability of AI technology adoption.

- The effect of distance to all-weather road on AI adoption decision is found to be significant and negative. Higher the distance to the nearest all weather road, the opportunity cost of labour increases and thus adoption decision of AI technology is negatively affected. But, the influence of the distance to all weather roads on extent of adoption is not significant.
- For those farmers who find grazing land easily available in the locality, the input cost will decline. As a result, they may find rearing indigenous breed economical and hence are unlikely to adopt AI technology. The findings of the study counters this hypothesis as significant positive relationship is observed between adoption of AI technology and availability of grazing land. It is found that farmers having easy access to grazing land are 1.58 per cent more likely to adopt AI technology. The reason may be that farmers are initially indifferent about the input cost and may decide to try the technology.
- Farmers with a new farm are more likely to adopt the AI technology compared to the farmers having older farm. Similar significant and negative relation is witnessed between the extent of adoption of AI technology and number of years since the farmer started the farm. With one additional year, older dairy farms may have the probability of decrease in the adoption and extent of adoption by 0.6 per cent and 0.02 per cent respectively.
- There can be direct demotivating effect on adoption of a technology when distance from the source of the necessary equipments/inputs and technicians required for performance of AI technology is concerned. However, findings of the present study go against the negative hypothesized relation between distance to AI centre and adoption of AI technology. It has been found that one kilometer increase in the distance to AI centre from farmer's house leads to 11.6 per cent increase in the probability of adoption of AI technology by the farm households. The justification in support of the positive relation may lie in the following. During the survey, it was found that only 10.22 per cent of the farm households had inseminated their cattle at AI centre. The inseminators use two wheelers to visit the farming households and they find it profitable to inseminate farms located at distant places from AI centre. They can

charge much higher fees than the usual rate in the name of higher fuel requirements and thus extra income allures them to service AI more to farms with longer distance from AI centre. Similar positive but non-significant relation is witnessed between distance to AI centre and extent of adoption of AI technology.

- Increase in herd size significantly and positively affects adoption of AI technology at 1 per cent probability level. However, increase in herd size significantly lowers intensity of AI technology adoption. This implies that increase in the number of cattle heads to a certain extent may embolden farmer to accept more innovative AI technology because he is gaining confidence to rear high yielding crossbred cows. However, it may happen that with further increase in the herd size with more crossbred cattle his capacity in cattle herd management and individual monitoring of stages of heat of individual cows are constrained and AI adoption intensity may decline.
- There is significant (at 1 per cent probability level) increase in the adoption and extent of adoption of AI technology with increasing number of years since first heard about AI (proxy to extension service availability). It is found that with one additional year increase in the period between first knowing about AI and adoption increases the probability of adoption and extent of adoption. Thus, access to information about AI is very crucial for adoption decision of AI technology.
- There is significant (at 1 per cent probability level) decrease in the likelihood of adoption of AI technology when farmers self-assess a new technology to be risky. There is 28.9 per cent decrease in the probability of his/her adoption of AI when he/she feels adoption of AI to be risky. Corollary to this, there may be 8.69 per cent decrease in the probability of extent of adoption of AI when the farmer considers that adoption of AI technology is risky.

8.1.9. Constraints to Adoption of Crossbreeding Technology

- Among the various constraints farmers perceive to hinder their adoption of crossbreeding technology, the most severe constraints reported by the sample farmers are the high cost of fodder and concentrate followed by higher requirements of feed and fodder by crossbred cattle. The other constraints hindering adoption of crossbreeding technology in order of severity are high overall cost of rearing crossbred

cattle, higher requirement of care by crossbred cattle, getting green fodder is difficult etc.

- The least severe constraints perceived by the sample farmers is the unavailability of regular milk market followed by exposure to seasonal flood hampering the rearing of crossbred cattle, favourable attitude towards growing grain and other crops than growing fodder crops, long calving interval of crossbreds etc.
- High cost of AI followed by lack of progeny tested bull and poor conception rate of AI are the important breeding constraints; while longer calving interval, non-availability of the inseminator round the clock, lack of AI centre in the vicinity etc. are the least important breeding constraints affecting adoption of crossbreeding technology
- Regarding feeding practices that may affect adoption of crossbreeding technology, high cost of fodder and concentrate is the most serious constraint as perceived by the sample farmers followed by the farmer's perception that crossbreds require higher amount of feed and fodder.
- Among the constraints relating to institutional and infrastructural services, lack of knowledge of the farmers on recommended management practices is the most serious constraint in adopting new dairy technology such as crossbreeding. This is followed by lack of institutional credit facility as one important constraint the farmers perceive. Non-availability of regular milk market is the least important constraint in crossbreeding technology adoption followed by distant location of AI centre.
- In the category of socio-psychological constraints affecting negatively the adoption of crossbreeding technology, farmer's perception on high cost of rearing crossbred cattle is found to be the dominant constraint. 'Farmer's perception on exposure to seasonal flood hampers rearing of crossbred cattle' is the least important socio-psychological constraint followed by 'AI results to more male calves' as reported by the sample farmers in the study

8.2. Conclusion

Analyses based on both primary and secondary data point out that higher productivity of crossbred cattle may be considered as the most important driver of enhancing dairy production in a milk deficit state like Assam. The study reveals that adoption of crossbred

cattle has favourable impact on raising marketed surplus and farm profitability considering several other control factors. The study points out through descriptive comparisons based on *t*-test that crossbred cattle has significantly higher annual milk productivity by 537 litres over the non-descript cattle. Moving beyond the implications of crossbred cattle adoption on productivity parameter of the smallholder dairy farmers, the study tried to explore whether crossbred cattle adoption has wellbeing impact on the dairy farmers of the state. The wellbeing of the farmers is measured as household income disaggregating by sources, consumption of protein rich high value commodities and farm employment using semi-parametric technique, namely propensity score matching. It is found from the study that the total household income after adoption of crossbred cattle significantly rises by in the range of Rs. 46,299.54 to Rs. 54,389.08 (for alternative matching algorithms) over the counterfactual non-adopters. The increase in net dairy income being the dominant component of total household income is in the range of Rs. 44573.03 to Rs. 44904.27 ($p=0.000$) over the farmers with only the non-descript cattle. The treatment impact of net dairy income per milch cattle per day of crossbred cattle adopters increases in the range of Rs. 42.06 to Rs. 42.21 compared to the matched non-adopters. Other income components of the total household income namely crop and/or plantation income and livestock income shows positive but statistically non-significant effects on the dairy farm households after adoption of crossbred cattle. Furthermore, the average treatment effect of crossbred cattle adoption on consumption of high value commodities indicates a positive and significant increase for the per capita daily consumption of milk and meat. Furthermore, adopter households also have significantly higher average per capita daily consumption in the range of 105.87 to 109.55 grams of milk and milk products and 6.51 to 8.40 grams of meat consumption. Average fish consumption difference between similar pairs of households of adopter and non-adopter of crossbred cattle shows positive but statistically non-significant effects across matching estimators. Another outcome indicator of household wellbeing is the increased labour use ex-post the adoption of crossbred cattle. The study shows that adopters have statistically significant increase in total labour use after high yielding crossbred cattle adoption equivalent to the range of 10.27 to 10.55 person days per month ($p=0.000$) in relation to matched non-adopters. The significant rise in total monthly person days is also evident for both male and female workers. Thus our hypotheses that “Adoption of

crossbreeding technology enhances dairy productivity and production and other wellbeing indicators such as income, employment and consumption of protein-rich commodities of the adopter farmers” is partially accepted.

The results of Cragg (1971)’s Double-Hurdle model indicate that there are multiple factors influencing the decision to adopt and extent of adoption of crossbreeding technology (artificial insemination). The study shows that education of the household head and amount of land allotted for fodder cultivation affects positively the decision to adopt crossbreeding technology. Better access to credit services is important as there is a positive and significant relation between credit access and extent of crossbreeding technology adoption. Physical environment characteristics such as distance from farm household to market and all-weather road affect adoption of artificial insemination technology negatively implying significance of market linkages and expansion of rural roads in increasing the rate of adoption of artificial insemination technology. The study has also found ‘availability of grazing land’ and ‘beneficiary of existing dairy development programmes’ as positive and significant factor for crossbreeding technology adoption. Relatively new farms are found to be significantly affected more towards adoption and extent of adoption of artificial insemination technology as there is a negative significant relationship between the two. It is found that distance to AI centre is positive and significant implying that AI services are mostly carried out at farmers’ door step. Access to local breeding bull negatively influences both adoption and extent of adoption of artificial insemination which has the implication that risk-averse farmers finding local breeding bull easily at the locality may not adopt and intensify artificial insemination. Farmers with bigger herd size are adopting crossbreeding technology more but further increase in the herd size is found to negatively affect the intensity of adoption of the technology. This may be attributed to the difficulty to pay for the larger number of services with a bigger herd size or due to declining conception rate resulting from the failure to individually monitor the stages of heat of the cattle. Number of years since knowing about AI is taken as a proxy to extension effort and awareness programme. The results of the Double-Hurdle model show that farmers knowing about AI much before are more likely to adopt and increase the intensity of use of AI technology. It is also found that the chances of adoption and extent of adoption reduced by 28.9 per cent and 8.69 per cent respectively for those farmers who consider artificial insemination technology

to be risky. Thus, our second hypotheses of the study, “Adoption of crossbreeding technology is influenced by various farm, farmers, physical environment and perception factors” also gets partially accepted. However, adoption and use intensity of crossbreeding technology is contingent upon various breeding, feeding, management and socio-psychological constraints identified among the sample farmers. Prominent among these constraints are the high cost of rearing crossbred cattle due to higher cost of feed and fodder and difficulty in getting green fodder, higher requirement of care and management by the crossbred cattle, lack of knowledge on recommended management practices while rearing crossbred cattle etc.

8.3. Policy Suggestions

The important policy suggestions emerging from the findings of the study are summed up in the following points:

- As the education of the household head positively affects adoption of artificial insemination technology at farm level, intervening in the rural education may influence positively the adoption of the technology among smallholder farmers in Assam. Again, since access to credit affects positively the extent of adoption of AI technology, easy availability of credit facility may encourage the intensification of AI technology among the dairy farmers in the state.
- Based on the finding, the study recommends that facilitating the farmers with dairy development programmes such as subsidized feed and green fodder seed distribution may help to motivate farmers towards adoption of crossbred cattle. However, it is found that the relationship between access to dairy development programmes and extent of adoption of AI is non-significant suggesting that once adopted the technology, withdrawal of this kind of support do not affect negatively the intensification of AI technology of the dairy farmers.
- The finding of the study recommends that deployment of more AI technicians in the rural areas of the state and castration of local breeding/scrub bull due to risk averse

farmers' knack for easily available and cheaper technology will help in increasing the adoption rate of crossbreeding technology.

- Proxy variable to extension services and awareness programme, namely 'number of years since first knew about AI' points out strengthening of the extension services of the government for making people aware about the AI technology to raise the rate of adoption of crossbreeding technology. Since farmers are by nature risk averse, they are found to be reluctant to adopt new technology due to farmers' perceived risk embodied in the artificial insemination technology. If this perception can be reversed through better extension services and awareness programme, the rate of adoption and use intensity of AI are likely to increase in the state.
- Since crossbreds require higher amount of feed and fodder and according to farmers' perception, high cost of feed and fodder affects negatively the intensification of crossbreeding technology, emphasis should be given on the development of feed and fodder market to make them easily available and affordable for the dairy farmers of the state.

8.4. Limitations of the Study and the Scope for Future Research

Some of the limitations of the study as observed by the researcher during the course of this study are pointed out below:

- The present study is based on cross sectional data of 245 sample farmers collected through a field survey from three districts of Assam. The study would have been more effective and clearer to depict a picture of the cattle crossbreeding scenario of the state if sample size could have been increased by covering more districts in the primary survey. Considering the resource and time constraint, the researcher had to stick to the present sample size and admits it as one of the limitations of the study. Increasing the sample size and studying cattle crossbreeding scenario in the state can be a scope for future research.
- The primary survey disregarded the adoption determinants and impact of crossbreeding of the buffalo population. This was given less attention in the study because diffusion of crossbreeding of indigenous Swamp buffalo using Murrah buffalo

is very limited in the state due to silent heat symptoms of buffalo. Again, the secondary data also reveals that proportion of buffalo population in the total bovine population is also quite less in the state (almost 6 per cent only). Thus, a study of overall bovine population (including buffalo) of the state with respect to crossbreeding can be good scope for future research.

- Impact evaluation of crossbreeding technology adoption is done using propensity score matching that creates a counterfactual situation to address selection bias by matching the treatment group with the control group based on observable variable. Thus, addressing the selection bias based on unobservable variables such as motivation and risk perception of the farmers to adopt crossbreeding technology have been ignored in the estimation of propensity score. This is an important limitation of the present study. Estimation using more recently development method, namely Endogenous Switching Regression (ESR) may address selection bias and provide better impact estimates.
- Finally, the study is carried out in a controlled environment using primary data collected from the field. Variations may arise in the results of the analyses considering that they are all done with “reported” data and under no controlled environment.

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Appendix 4.1: Questionnaire Administered in the field to collect Primary data

“Dairy Productivity and Crossbreeding Technology Adoption in Assam: Impact and Determinants”

A study undertaken for the award of the degree of Doctor of Philosophy (PhD) by the Department of Humanities and Social Sciences, IIT Guwahati, Guwahati-39, Assam, India. Ph-91-(361)-2582600. Name: Baban Bayan (Reg. No. 126141005) Supervisor: Prof. M.K. Dutta

1. Household General Data

1.1. Household Identification

District		Block	
Village name		Village ID	
Household Head name		HH head's father's name	
Respondent's name		Respondent's relation with HH head	
Address		Phone number	

1.2. Household head characteristics

Gender	Age (Years)	Years of Schooling	Ethnicity	Primary		Secondary	
				Occupation [#]	Place [*]	Occupation [#]	Place [*]
m - f							

[#] 1=Dairying, 2=Agriculture (other than dairying), 3=Business, 4=Wage earner, 5=Govt. Job, 6=Others (specify)

^{*} 1=Farm, 2=Village, 3=District, 4=State, 5=Others (Specify)

1.3. Household member characteristics

No. of HH members	Adults (>14 y)		Young (6-14 y)		Children (<6 y)	
	Male	Female	Male	Female	Male	Female
Total in HH						
Working on dairy farm (full time)						

Working on dairy farm (part time)						
Student						
Working/employment other than dairy farm						

2. Asset, Accessibility and Food

2.1. Access to household asset

2.1.1. Land ownership

Land Type	Own Land	Land leased-in	Land leased-out	Land Mortgaged-in	Land Mortgaged-out	Total Operational Holding
Homestead/Courtyard						
Crop Land						
Land for Fodder Cultivation						
Other (specify)						

2.1.2. Livestock ownership

	Currently Keeping (Female)			Currently Keeping (Male)			Purchased last 12 months		Sold last 12 months		Number (currently keeping)
	in milk	dry	young stock	adult animal used for work	adult animal used for breeding	young stock	Type*	number	Type*	number	
Cattle – crossbred											
Cattle – indigenous											
Buffalo-crossbred											
Buffalo - indigenous											
Goat											
Sheep											
Pig											
Poultry (local)											
Poultry (commercial)											
Others (Specify)											
2.											

*Type: In milk=1; Dry=2; young (female)=3; adult animal used for work=4; Young (male)=5; others (specify)=6

2.1.3. Household access to amenities and asset

House type*	Code=	Bullock cart	y / n
No. of rooms		Four wheelers	y / n
Cooking Gas	y / n	Tractor	y / n
Latrine (sanitized)	y / n	Power tiller	y / n
Electricity	y / n	Thrasher	y / n
Mobile Phone	y / n	Cello tube-well	y / n
Television	y / n	Accessed to subsidized Food (Ration Card)	y / n
Two wheelers	y / n	BPL Card	y / n

* pucca house=1; semi-pucca house=2; kutcha house=3

2.2. Access to institutional asset

2.2.1. Credit access and saving strategy

Whether access to credit last 5 years.	y / n	If yes, amount received (Rs)	
1 st Source	formal / informal	Spent on*	
2 nd Source	formal / informal	Spent on*	
Any savings?	y - n	How/where [#]	

*livestock related activities=1; buying of land=2; construction activities=4; agriculture (other than lvstck)=4; social ceremonies=5; any other (specify) =6 [#]commercial bank=1; Post office =2; Group Savings =3; any other (specify)=4

2.2.2. Access to extension and infrastructural services

a. Do you know the KVK agent of your village?	y - n	k. Did you ever attend in a farmer's orientation camp/Friday evening meeting	y - n
b. If yes, how frequently you meet him?	d - w - m - sm - y - n	l. Membership of DCS/MPI	y - n
c. Did you consult him on dairy farming related problems during last 12 months?	y - n	m. If yes, no of years since becoming a member of DCS/MPI	
d. If yes, have you followed his	Code=	n. What is the distance to nearest	

advice and found useful?*		village market? (km/walking hour)	
e. Comment on extension service [#]	Code=	o. What is the distance to all-weather road? (in metre)	
f. Did ever participated in a calf rally?	y - n	p. Do you have access to BMC?	y - n
g. Do you know the VFA/GM of your village?	y - n	q. Do you have access to grazing land?	y - n
h. If yes, how frequently you meet him?	d - w - m - sm - y - n	r. Whether a beneficiary of govt. dairy development programme	y - n
i. Did you consult him on dairy farming related problems during last 12 months?	y - n	s. If yes, name the programme you are benefitted from.	
j. If yes, have you followed his advice and found useful?*	Code=	t. No of years since starting of dairy farming (Farm with CBs)	

* followed and found useful=3; followed but did not find useful=2; did not follow=1

[#] highly satisfied=5; partially satisfied=4; no comment=3; somewhat dissatisfied=2; highly dissatisfied=1

2.2.3. Food access

How often does your HH	Milk	Fish	Meat	Vegetables	Fruit
Eat/drink (weekly frequency)					
Volume (kg/litre)/meal					
Source of availability*	Code=	Code=	Code=	Code=	Code=

* Purchased=1; 2= home grown; both=3

3. Breeding, Reproduction and Feeding Characteristics

3.1. Breeding characteristics

a. Whether heard about AI?	y / n	m. Average number of AI services taken to conceive for the last calf born.	
b. If yes when did you first hear of AI (year)?		n. Number of services taken at farm (during last 5 years).	
c. What was the source of information?*	Code=	o. Number of services taken at AI centre (during last 5 years).	

d. Have you tried AI?	y / n	p. What is the distance to AI Centre? (walking hour)?	
e. If no, state the reasons.	1. 2. 3. 4	q. Charges imposed for carrying out AI services.	Rs.....(@ farm) Rs.....(@ AI centre)
f. If yes, when did you first try AI (year)?		r. Whether you go for natural service (NS)?	y / n
g. Who did AI for your animals? [#]	Code=	s. Do you have access to exotic bull for the dairy animal at your farm?	y / n
h. Are you still using AI?	y / n	t. If yes, how much to be paid per service through exotic bull?	
i. If no, when did you stop using AI (year)?		u. Do you have easy access to local breeding bulls for the dairy animal at your farm?	y / n
j. Reasons for discontinuation of using AI	1. 2. 3. 4	v. Number of calf born through NS in your farm during last 5 years?	
k. Number of calf born through AI in your farm during last 5 years		w. Do you find semen straw available at AI centre/with VFA (or GM) when needed?	y / n
l. Years of Experience with AI if AI is being continued in the farm		x. Farmer's self Assessment of Riskiness of going for AI?	Risky / not risky / DK

* Extension agent=1; cooperative member=2; other farmer=3; VFA=4; GM=5; Radio=6; others (specify) =7

[#] AI Administrator: VFA=1; GM=2; Others (specify)=3

3.2. Reproduction and lactation characteristics of owned animals

Dairy animal	Covered by AI	Covered by Impr. Bull	Covered by local breeding bull	Age of 1 st calving [months]	Calving interval [months]	Lactation length [months]	No. of lactation
Cattle (ind)							
Cattle (CB)							
Buffalo (ind)							
Buffalo (CB)							

3.3. Feeding Characteristics

3.3.1. Daily feed ration for adult crossbred cattle

	Feed name	Kg/day/animal	Domestically available (kg)	Amount purchased (kg)	Price /kg	Availability constraint (1= easily available; 2=not easily available)	Reasons for not easily available
Dry fodder							1.
							2.
							3.
							4.
Green Fodder							1.
							2.
							3.
	Grazing time						4.
Concentrates							1.
							2.
							3.
							4.

* Imputed price of locally available feed resources should be stated

3.3.1. Daily feed ration for adult indigenous cattle

	Feed name	Kg/day/animal	Domestically available (kg)	Amount purchased (kg)	Price /kg	Availability constraint (1= easily available; 2=not easily available)	Reasons for not easily available
Dry fodder							1.
							2.
							3.
							4.
Green Fodder							1.
							2.
							3.
	Grazing time						4.
Concentrates							1.

							2.
							3.
							4.

* Imputed price of locally available feed resources should be stated

4. Milk Production and Utilization

4.1. Milk yield of lactating animals (according to bovine type) during the last 12 months

Animal Type	Avrge milk yield (l/day/anim.)	Maximum yield		Minimum yield		Major reason behind yield variability
		(l/day/anim.)	Up to lactn month	(l/day/anim.)	Lactn months post peak	
Cattle (Ind)						
Cattle (CB)						
Buffalo (Ind)						
Buffalo (CB)						

4.2. Utilization of household milk production

Particulars	Average daily HH milk prod	Sold to vendor/market	Sold to Cooperative	Sold in retail form	Kept for HH consumption	Milk offered to relatives/neighbors	Processed* for home consumption	Processed ¹ for sale
Volume								
Price/litre								
%ge use	100							
Distance [km]								

* Processed product: curd=1; cream=2; ghee=3; sweets=4; channa=5; other (specify)=6

5. Labour Requirements

Operations	No. of hours required/day	No. of hired labour/day		No. of Family labour/day		Total person days/month	
		Male	Female	Male	Female	Male	Female
Feeding & grass collection							
Milking							

Marketing of milk							
Cleaning/washing of animals and cattle sheds							
Total							

6. Milk production cost (during last 12 months)

Particular	Amount	Cost per unit	Total amount
Feed (kg)			
Green Fodder (Kg)			
Dry Fodder (kg)			
Artificial Insemination (number)			
Natural Service (number)			
Medicines Cost (Rs)			
Veterinary doctor fee (Rs)			
Hired labour (number)			
Interest on loan (Rs)			
Cost on cattle sheds (repair) (Rs)			
Any other cost (specify)			
Total Cost			

7. Revenue receipts on sale of milk (during last 12 months)

Milk production (litres)			
Sales (litres)			
Amount received (Rs)			
Total amount			

8. Annual household income (during last 12 months)

Sources	Income (Rs)
Cropping and Plantation	
Livestock (excluding dairy)	
Wage labour	
Dairy	
Employment other than dairying and agric.	
Others (Specify)	
Overall total income	

9. Farmer's perception* on constraints to dairy farming

sl. no.	Constraints Regarding Breeding Practices						
1.	Poor conception rate i.e., poor result of AI	--	-	-/+	+	++	n.a.
2.	Too much repeat breeding through AI	--	-	-/+	+	++	n.a.
3.	Long calving interval	--	-	-/+	+	++	n.a.
4.	Non-availability of semen at AI centre	--	-	-/+	+	++	n.a.
5.	Non availability of inseminator round the clock	--	-	-/+	+	++	n.a.
6.	Lack of PD facilities	--	-	-/+	+	++	n.a.
7.	Lack of progeny tested bulls	--	-	-/+	+	++	n.a.
8.	Lack of AI centre in your vicinity	--	-	-/+	+	++	n.a.
9.	Inadequate Knowledge of AI	--	-	-/+	+	++	n.a.
10.	Animal do not come to heat on time	--	-	-/+	+	++	n.a.
11.	High cost of AI	--	-	-/+	+	++	n.a.
12.	Natural Service is favourable than AI	--	-	-/+	+	++	n.a.
Constraints regarding feeding practices							
13.	Crossbreds require higher amount of feed and fodder than indigenous cattle	--	-	-/+	+	++	n.a.
14.	Lack of knowledge on treatment of poor quality roughages	--	-	-/+	+	++	n.a.
15.	The fodder and concentrate cost is much higher	--	-	-/+	+	++	n.a.
16.	Lack of common grazing field	--	-	-/+	+	++	n.a.
17.	Lack of knowledge on balanced feeding	--	-	-/+	+	++	n.a.
18.	Getting green fodder is much difficult now a days due to the scarcity	--	-	-/+	+	++	n.a.
19.	Favourable attitude towards growing grain and other crops than growing fodder crops	--	-	-/+	+	++	n.a.

Constraints regarding institutional & infrastructural practices							
20.	Lack of knowledge of recommended management practices	--	-	-/+	+	++	n.a.
21.	Unavailability of veterinary facilities nearby	--	-	-/+	+	++	n.a.
22.	Unavailability of regular milk market	--	-	-/+	+	++	n.a.
23.	Poor extension support	--	-	-/+	+	++	n.a.
24.	Lack of institutional credit facility	--	-	-/+	+	++	n.a.
25.	Distant location of AI centre	--	-	-/+	+	++	n.a.
Socio-psychological Constraints							
26.	Crossbred cattle are susceptible to diseases	--	-	-/+	+	++	n.a.
27.	Crossbred cattle require comparatively more care in rearing	--	-	-/+	+	++	n.a.
28.	Crossbred cattle cannot tolerate high temperature.	--	-	-/+	+	++	n.a.
29.	Overall cost of rearing crossbred cattle as compared to indigenous cattle is very high	--	-	-/+	+	++	n.a.
30.	AI results to more of male calves	--	-	-/+	+	++	n.a.
31.	It is uneconomical to rear crossbreds due to poor drought capacity of crossbred male	--	-	-/+	+	++	n.a.
32.	Exposure to seasonal flood hampers the rearing of crossbred cattle	--	-	-/+	+	++	n.a.

* -- strongly disagree; - disagree; -/+ neither agree nor disagree; + agree; ++ strongly agree; **n.a.** not applicable

10. Investigator's remarks

Publications:

Peer Reviewed

Bayan, B. and Dutta, M.K. (2018) “Effect of crossbred cattle adoption on employment generation in Assam” *Indian Journal of Dairy Science*, Vol. 71, No. 1

Bayan, B. and Dutta, M.K. (2017) “Crossbred cattle adoption and its impact on income and household milk consumption among dairy farmers: Empirical evidence from Assam”. *Indian Journal of Agricultural Economics*, Vol. 72, No.2

Abstracts in Scientific Meetings

Bayan, B. Genetic Improvement of Indigenous Cattle Stock and Welfare Gain of the Smallholder Dairy Farmers: Empirical Evidence from Assam, India” *conference on ‘Sustainable Development Goals: India’s Preparedness and Role of Agriculture*, International Food Policy Research Institute (South Asia Office) NASC, Pusa, New Delhi, 11-12th May, 2017

Bayan, B. Factors affecting decision to adopt artificial insemination (AI) technology by smallholder dairy farmers in Assam: A double-hurdle approach. *Ph.D. Consortium 2017*, School of Management, IIT Bombay, 24-25th January, 2017 (Adjudged the best paper in the consortium)

Bayan, B., and M.K. Dutta. Determinants of adoption and use intensity of AI technology in dairy farms: A study from Assam. *53rd Annual Conference of The Indian Econometric Society (TIES)*. Bhubaneswar, Orissa, 22-24th December, 2016

Bayan, B., and M.K. Dutta. Impact of adoption of crossbred cattle on income and consumption of high value food commodities by the smallholder dairy farmers in Assam. *24th Annual AERA Conference on Agriculture for Nutrition Security*. ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, 15-17 December, 2016

Bayan, B., and M.K. Dutta. Adoption of high yielding crossbred cattle and increased labour use in smallholder dairy farms in Assam: A matching approach. *58th Annual Conference of The Indian Society of Labour Economics*, Indian Institute of Technology Guwahati, Assam, India 24-26th November 2016

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