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NEW DIMENSIONS OF TECHNOLOGICAL TRANSFORMATION IN INDIAN AGRICULTURE: A STUDY FROM ASSAM

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Abstract- Technological transformation is the most crucial factors which determine the pattern and pace of agricultural growth. The transformation includes all the available means for improving the efficiency of scarce resources into products which satisfy human wants. It manifests itself in the use of new inputs and knowledge leading to an upward shift of the production function in the long run. Technological advance has two general properties. It refers to the shift in the way resources are used such that either a larger output is obtained with a given total input of resources or the same output is produced with a smaller amount of input. Technological transformation started in India since 1966 resulting 'Green Revolution' in the country. But it was confined to selected states. Assam, situated in the north east region of the country was not the part of that revolution. Recently the agriculture sector of the state has experienced some changes. The farmers have started use of tractor, power tillers for ploughing, shallow tube well etc. for irrigation and chemical fertilizer. The present paper highlights the findings of the survey which was conducted by the author to investigate status and problems of use machine machinery etc. in agriculture in the state.

Keywords- Green Revolution, Resources, Shift, Technological Transformation, Upward,

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1. Introduction

Modernization of agriculture is not a normal process. It needs technological transformation by the people concerned. Some elements influence modernization of agriculture of a particular area. **Ross (1970)** in his study found agricultural modernization process is affected by leadership, availability of technology, necessary farming inputs, available credit facilities, favorable crop relationship, and control of nature. **Mamud (1978)** argued for constant and close interaction between science and rural environment in order to enable technology to assist the rural people to break away from the traditional methods of farming. The technologies should be applicable at the farm level and need not to be the mostly sophisticated. Rather they should be easily assimilated and suitable to the farmers as well as to the environment. **Bounting (1979)** observed technology has been increasingly recognized as a powerful influence on economic growth, and the transfer is accompanied by some new problems, which are social and economic in nature.

Modernization of agriculture is said to be unemployment creator. Agricultural mechanization is not supported by many development economists on the ground that it reduces employment opportunity in agriculture. **Robertson (1981)** studied the impact of technological innovation and pointed that in certain planned economies, technological advances did not create unemployment but did eliminate drudgery and permit shorter working period. He argued that a national policy of restraining and redeployment should be a part of the management. **Samanta (1983)** studied the role of science and technology in rural and economic development. He found that inappropriate technologies lead to unemployment, the waste of scarce resources and destruction of the environment and the disturbance of socio cultural equilibria. He also observed that appropriate technology may prove inappropriateness of the information gathered about the farmer's need and the resource endowment were inapplicable or inaccurate. Therefore, he suggested for agricultural technology to be chosen for transfer considering the local applicability, attitudes of the users and also the nature of farming whether subsistence or commercial. **Chutikul (1985)** indicated that farming system, research approach, together with rapid rural appraisal is very useful in identifying appropriate technology for small scale farmers. He found technological progress in agriculture may proceed along a number of alternative routes. In one extreme form, technological change may be highly capital extensive, labor saving type. Technological progress along this line is marked by large scale mechanization of production process and replacement of

human and animal power by use of heavy capital equipment. Emphasis is on augmenting productivity per workers than on maximization of productivity per unit of land. This route of technological advancement of agriculture is appropriate for a country where population is scarce, land and capital are abundant but manual workers are in short supply. But in rural areas of most of the developing countries the land parcels are small, capital is scarce and labor is abundant.

Bhatia (1999) observed strong relationship between rural infrastructural development and level of per hectare yield of food grains. **Dev (2002)** suggested for greater need of public investment in agriculture, irrigation, credit availability, better marketing of agricultural products, research and development along with adequate pricing and other incentives for private investment to achieve agricultural growth. **Roy and Bezbaruah (2002)** found, in spite of population pressure, in underdeveloped countries like India, most parts of agricultural land remain used for only one round of cultivation in a year. They observed, in these countries, considerable agricultural growth can be attained through double or multiple cropping only. Multiple cropping requires timely and adequate water supply, application of fertilizers, use of short term crop varieties of yield and quicker preparation of land. Thus significant increase in cropping intensity can be expected only with some improvement in the technique of cultivation such countries.

Thus it is found that the main challenges in Indian agriculture are (1) the small farmers are more in the country and its number is increasing. (2) The number of labor is decreasing. (3) Indiscriminate urbanization (peri urbanization) has affected agriculture most adversely. Land has degraded. (4) Demand for water exceeds supply. Salinisation is a becoming a problem. (5) Seed is primary input but seed replacement rate is quite low. Major constraint is availability. (6) Legal and regulatory rules are not changed. (7) Under nutrition is rising. (8) Food security is under threat.

From the survey, it is found the same situation is going in Assam as observed by the authors mentioned here. In the state of Assam, the percentage of small farmers is increasing rapidly because of peri urbanization, absence of effective land laws and breaking of joint family system it is observed, the irrigation facility in the state is very limited and the land laws are not in favor

of small farmers. On the other hand, the urbanization in the state is found unplanned. The hypotheses fixed for study have resemblances to these observations.

From the available literatures, it is found, the main challenges to Indian Agriculture are: viability of small farmers, slowdown in growth, regional/sectoral disparities, efficiency, question of sustainability, poor infrastructure, poorly functioning agricultural markets, agrarian distress, low income, threat to food security and fluctuating growth.

Swami Nathan (1973), the famous agricultural economist pointed that technology is becoming available but the mechanism for transferring it to illiterate and small users in an effective manner does not exist. When technology has to be transferred it should be tested whether it suits the local needs**.** Testing of technology is normally absent. **Singh (1974)** in his occasional paper presented in Haryana Agricultural University studied the transfer of farm technology to small farmers and reported that technology innovations are not fully tested under diversified local conditions before they are released. **Govindarajan (2014)** cited the example of National Agro Foundation which has been involved in a range of interventions—infusion of technology, soil enrichment, efficient farm and water management, improved cattle development, functional literacy, rural sanitation and public health, human resource development, establishment of self-help groups particularly among women, self-employment opportunities and facilitating institutional credit—to address the problem of farm productivity in India. NAF works in about 250 Villages in Tamilnadu reaching 30,000 rural families. A large part of NAF's effort with farmers is to help break their initial emotional barriers to new technologies. This has provided the platform to launch into other initiatives. The success of these measures has had a demonstrative impact on the farmers' willingness to adopt and internalize new technologies. This may be considered an attitudinal breakthrough. He remarked reducing income inequality is not just a matter of charity; it is a challenge for innovation. NAF is an interesting experiment. The problem is so large; will more corporations step forward to collaborate with organizations like NAF to tackle this challenge? **Report on Africa (2016)** said "there is a massive opportunity to reframe the current social and economic costs associated with the low productivity of the agricultural sector. What has – up till now – been an area of relative weakness for the African continent, can be recast as an area of strength and, more importantly, one of the fastest options for feeding, employing, and

lifting millions of people out of poverty. Agricultural transformation has proven to be a complex endeavor, but is becoming increasingly understood as pockets of successful interventions spring up across the continent. New technologies – especially in the ICT realm – are bringing with them new ways of achieving and scaling success." It was also said in the Report that- "critical to realizing this opportunity will be shifting the development of the sector from 'agriculture as a way of life' to 'agriculture as a business'. The public-sector has an essential role to play in fostering a private-sector led transformation of agriculture. Farmers, entrepreneurs, and investors alike will find a way to develop thriving agribusinesses if given the opportunity in the form of access to sufficient and affordable capital, access to markets and the right overall conditions in terms of policy and infrastructure. Lessons have been learned from emerging successes in the African continent, as well as internationally, on how to create these conditions, while new technologies are opening up new opportunities to modernize agriculture in a particularly inclusive way. It is now for public sector actors to do what is possible in their power to provide these conditions and help build the partnerships necessary to catalyze investment."

In the last decade, there have been signs of stagnation everywhere. Overall land under food grains has remained at 120 million hectares and is showing signs of dropping further. Public investment in agriculture as percentage of GDP has dropped from 3 % to around 1.7%. Addition to irrigation was very low compared to previous decades. Ground water level in many places has dropped rapidly and the shortage of water for farming has reached crisis level. Worse is that there has been no technological back through that can boost the yields of major food grains to bring a second Green Revolution. According to a recent report of national sample survey 40% of the farmers want to opt out of their current profession. Every year, large numbers of farmers have committed suicide out of despair over failing crops and impossible high debt**.** Swami Nathan therefore remarked that the situation is deteriorating rapidly and the entire farming sector is heading for a total collapse if no rapid remedial measures are taken.

Piper (2017) made an observation that agriculture has faced a rapid transformation from traditional to modern form. Whereas by the 1960s, the benefits of what was nicknamed the "Green Revolution" were apparent when successful new wheat varieties were made available in countries across the globe, in 2000s, Software and mobile devices helps farmers have better harvests. Like

many people, farmers started carrying mobile devices, which allowed them to stay connected to colleagues while in the field. This also meant they now had access to data needed while on-the-go, including the ability to place orders for seed or fertilizer at any time or in any place. **Chakravarty (2018)** opined that technology can transform Indian agriculture by addressing challenges related to quality, quantity, distribution and storage. Technology can assist the farmers in making right growing choices by carefully analyzing demand, pricing and fluctuations in weather conditions. This will create a better balance between supply and demand. Technology enabled farming tools can be a boon for small farms. Large machinery used in developed countries have very little applicability in most of our small farms. The key is to build mechanized processes suitable for small farms that reduce dependency on manual effort and results in better productivity. Technology based crop advisory around crop planning, pest control; disease mitigation can be very useful. Online marketplaces offering wide variety of authentic agri inputs that are backed by scientific agri-advisory can also help. Technologies that enable contract farming arrangements can help solve financing inefficiencies in the system. This reduces the farmer's risk with guaranteed off-take arrangements and agri-inputs supplied by the contracting company. Apart from with this, technology can also help farmers avail crop insurance and credit that are rightly priced. This can be possible by analyzing data from various sources including land records, weather analysis, historical and current satellite imagery and remote monitoring using drones. He also said in the traditional model, middlemen walk away with a large chunk of a farmer's income. E-marketplaces that can connect buyers and farmers directly can dis-intermediate the chain and offer better incomes to farmers. An effective cold chain system is the need of the hour for Indian agriculture. Most of the existing cold storage units are outdated. Technology enabled cold storage chains that are controlled using smart devices can prevent post harvest losses. Automated grading and sorting of crops using robotics and machine vision, can also reduce efforts and wastage in the supply chain. Sharing economy models that allow shared usage of high cost equipment like tractors can decrease financial burden on the farmers. This model can help farmers use tools and machines on a per usage basis instead of investing a high cost on outright purchase. With growing usage of smart phones, farmers can tap into the wisdom of the crowds, other knowledgeable farmers and agronomists to take inputs during the growing period.

The situation in Assam is no exception. Assam is a small state of India, situated in the north eastern region. In this state also these factors works as constrains to agricultural growth. Above

all, regular flood is a biggest challenge to agriculture in many places of Assam. It is said, "Assam is rich but its people are poor." The state is surrounded by independent countries. Bhutan and China on the North; China and Myanmar on the East; Myanmar and Bangladesh on the South and Bangladesh on the West surround the state. The state shares her boundary with the Indian states –Arunachal Pradesh to North and North East; Nagaland and Manipur to East; Mizoram to South; Tripura and Meghalaya to South West and West Bengal to West. The state is comprised of three physical divisions, namely, the Brahmaputra valley, the Barak valley and the Hill ranges. The Brahmaputra valley is the largest valley among the valleys. The North Eastern Region of India (NER) is a beautiful region of the country. The whole region is full of rivers, bills, hills, mountains and fountains. The Kamakhya temple of Assam, Tawang of Arunachal Pradesh, Serapunjee of Meghalaya is some of well known places, which attracts huge number of tourists this NER**. Dutt (1973)** in their case study of kharif programmed in SFDA, Nowgong district of Assam observed lack of irrigation, lack availability of inputs in time and misuse of credit as important constraints of agricultural growth**. Goswami (1980)** in his study from Assam found the cost of power tiller is high and hence majority of the farmers acquired them with financial assistance from external agencies. **Dutt (1982)** found high initial cost as the major constraints in use of power tiller by individual farmer. **Bezbaruah (1994)** found- the farmers in Assam in general are not averse to changes and that on the contrary, they are willing to innovate and experiment. He also observed farmers by and large have already adopted the use of new varieties of seeds. Another observation was that despite the widespread adoption of HYVs, the overall agricultural productivity in the state was not improved very much by the farmers because of the farmers' inability to use the technology extensively and effectively.

The climate of Assam is very damp as it is freely open to the moisture-laden winds from the Bay of Bengal and lies beyond the influence of the dry air current, which flows down the Gangatic plain during the hot weather. Total population of Assam stood 266.55 lakh as on Ist March 2001 (2.59% of the population of India). By and large, Assam is rural and nearly 76% of state's population depends on agriculture and allied activities for their livelihood and about 52% of the total labour force of the state is engaged in agricultural and allied activities. The area wise rank of Assam is twelfth among the political divisions. The state is endowed with various natural

resources like forest, mineral, water and agro natural resources. Still the state's economy remains poor.

The agricultural growth in the state is comparatively lower than that of the other main parts of the country. Only recently some changes have taken place in agriculture of Assam. Technological transformation is a new dimension to agriculture in Assam. The present paper is an attempt to highlight such changes. The **objectives fixed for investigation were:** (i) to measure the extent of technological transformation in agriculture of Assam and its variation across different conditions (ii) to assess the impact of technological transformation on farm's income, productivity and employment and (iii) to identify the factors facilitating and restricting spread of technological transformation in the state with an aim to prescribe policy measures.

2. Methodology adopted

The primary data were collected from a survey which was conducted by the author in 2005. The data were updated in 2016. The secondary data were collected from different Government and other departments. The sample data were collected from five out of six agro-climatic zones of Assam. The hills zone was not surveyed as the system and problems of agriculture in this zone are not different from others. The five agro-climatic zones were: (1) Lower Brahmaputra valley (2) Upper Brahmaputra valley, (3) Central Brahmaputra valley, (4) North Bank Plains and (5) Barak valley zone. From each zone, one Agricultural Development Officer's circle (henceforth referred as ADO circle) was selected. The circle was selected on the condition that it was fairly representative of the whole agro climatic zone, and necessary agricultural infrastructures were available at least in some villages under the circle. Thus ADO circles namely Bongshor, Furkating, Bhurbandha, Dumunichowki and Silchar were selected. Bongshor circle falls in Lower Brahmaputra Valley Zone and located nearest to the state's capital-Guwahati. In this circle, a large section of farmers cultivate vegetables along with paddy. Furkating circle falls in Upper Brahmaputra Valley Zone. This circle touches the boundary of Nagaland state and is inhibited mostly by other backward class people. Bhurbandha circle is located in Central Brahmaputra Valley Zone. It is regularly affected by flood. Dumunichowki circle is located in North Bank Plains Zone which is inhabited by mostly Muslim people. Silchar circle is situated in the Barak Valley Zone. This circle is inhabited by Bengali speaking Muslim people. The sample

design used in the survey was a two-stage random sampling. The villages constituted the primary sampling unit. The farm households were the secondary and ultimate sampling units in the survey. In the first stage, in each circle, five villages were selected at random on the condition that at least in one of the selected villages agricultural infrastructure like irrigation and credit was reasonably developed for use of modern machineries and implements. In the final stage, 10 % of farm households in each village were selected at random. Thus a total of 224 farm households were selected from five ADO circles.

Data on the general background and farming method were collected by interviewing a senior member, usually the head of the household. One Household Schedule of questions was used for this purpose. The data collected from the field were tabulated and processed by using the computer software-SPSS. The findings of the field study were compared with the available statistics.

3. Results and Discussion

3.1. Some findings

Since independence GOI is trying to transform Indian agriculture. As a result some changes have taken place. The present GOI is also trying for modernization of agriculture. The GOI, in 2016 has introduced a national policy to double farmers' incomes by 2022. Therefore, the Ministry of Agriculture & Farmers Welfare launched the national scheme called Pradhan Mantri Krishi Sinchai Yojana (PMKSY) with the aim of irrigating every Indian farm and improving water-use efficiency. GOI through its Digital India programme, is also working to transform the country's rural economy and create skilled jobs in rural areas. The Ministry of Communication and Information Technology, along with other ministries, is also working to bring reform in states' service delivery through GOI's Goods and Services Tax system, to establish a uniform interface for taxpayers with a common IT infrastructure, shared between the central government and the states. The Common Services Centres have been developed to provide access points for delivery of various electronic services to villages, to promote digital and financial inclusion, encourage rural entrepreneurship, and build rural capacities and livelihoods, offering a bottom-up approach to social change, particularly among India's rural citizens. New technologies in agriculture enable small farmers to shift from input-intensive to knowledge-intensive agriculture. Precision

agriculture can improve the timeliness of planting, secure the best market prices through market information and e-market reforms, provide fertilizer subsidies via direct bank transfers that eliminate or reduce the cost of financial intermediaries, and improve agricultural extension. Combined with improved seed supply and land and water management, which can in turn increase double and triple cropping, farmers' income can grow. The NAM (National Agriculture Market), introduced in 2016, is an online platform for farmers that integrates agricultural markets online, allowing farmers and traders alike to view all Agriculture Produce Market Committee-related information and services, commodity arrivals and prices, and buy and sell trade offers, thus helping farmers bid for the best prices across markets. GOI also launched a crop insurance scheme, the Pradhan Mantri Fasal Bima Yojana (PMFBY) in 2016, which now covers 37 million farmers. Additionally, GOI is investing in mapping all of India's aquifers, and using technology to manage water demand. Quantifying the relationship between rainfall and groundwater levels under alternative modes of irrigation and farming should enable prioritization of prospective water and irrigation investments.

According to a new market intelligence report by **BIS Research (2018)** the global smart farming market is expected to reach $23.14 billion by 2022, rising at a compound annual growth rate (CAGR) of 19.3% from 2017 to 2022. The market growth is primarily attributed to the increasing demand for higher crop yield, the growing penetration of information and communication technology (ICT) in farming, and the increasing need for climate-smart agriculture. In the coming years, smart farming is projected to create a massive impact on the agricultural economy by bridging the gap between small and large-scale businesses. The trend is not only pertinent in developed countries — developing countries have also realized its immense importance as well. As said in the report, in countries such as China and Japan, wide-scale deployments of smart phones and internet of things (IoT) systems have led to a rapid adoption of precision agriculture solutions. The governments of several countries have also realized the need for, and the advantages of these technologies, and thus, their initiatives to promote precision farming techniques are expected to drive the growth of the market further. However, such revolutionary change in farming practices not only come with opportunities but also certain challenges which prove to be a restraint in the growth of the market. The awareness and knowledge about newer agriculture technology are yet to spread extensively, especially in

emerging countries. Over the centuries, as farmers have adopted more technology in their pursuit of greater yields, the belief that 'bigger is better' has come to dominate farming, rendering small-scale operations impractical. But advances in robotics and sensing technologies are threatening to disrupt today's agribusiness model. “There is the potential for intelligent robots to change the economic model of farming so that it becomes feasible to be a small producer again,” says robotics engineer George Kantor at Carnegie Mellon University in Pittsburgh, Pennsylvania **(King, 2017).** Our study shows that some changes are taking place in the state of Assam, which is the leading state of North Eastern Region(NER) of India. Some of the findings are:

1. The use of machine-machinery in agricultural of Assam is a recent concept. Although the use of machine-machinery started in 1970s, it took place only in 1990s.
2. The use of technology has remained to some selected works only. The use of machine is increasing in the stage of threshing and transportation.
3. A large majority of farmers are found purchasing tractor and power for individual as well as for commercial use in agriculture. Thus A market of selling services of agricultural machinery is emerging in Assam. Selling of services of the machine-machinery especially of tractor is becoming a good business in the state among the farmers.
4. The tractors have also been used for non-agricultural purposes like transporting land/other materials. Many families are found purchasing tractor even after they don’t have own agricultural land only with the intension of earning through sale of its service to others.
5. Among the samples, 82% have purchased tractor and power tiller by their own money. The families having other non-agricultural incomes are found to be more interested in purchasing such machine-machinery considering the cost factor of maintaining bullocks and permanent labor.
6. Use of fertilizer and HYVs is now a common practice among the farmers. 99% sample farmers were found using fertilizer of which 91% used chemical fertilizer. 63% of sample farmers were found to be using HYVs in agriculture.
7. Among the various media of transmitting the idea of modernization, the influence of relatives and neighbors were found to be the most effective. Radio and TV programmes also contributed

in this regard. Agricultural extension network seems to have very little influence in the concept of use of machine-machinery.

8. Lack of electric power raises the cost of mechanization. Farmers generally use petrol or diesel as fuel. The price of those fuels is increasing every day. As a result cost of mechanization is found increasing day by day. The high cost has restricted the process of mechanization in the state.

9. The credit facility is inadequate to encourage the farmers to adopt modern methods of agriculture. A substantial number reported inability to finance (26%) and high cost of machine (34%) as their principal handicap in using machines-machinery in agriculture.

10. Mechanization is found to be taking place effectively in the areas where the agricultural infrastructures, especially irrigation facilities are available. The irrigation facility determines the degree of mechanization to a greater extent.

11. There is no clear indication that farm size determines mechanization. It was discussed that use of machine-machinery demands the farm size to be bigger. It was found irrespective of size of farm, the farmers have used the tractor, power tiller etc. in their agricultural fields. There is no indication that larger farmers tend to use machines-machinery in agriculture. Of course it is observed the larger farmers emerge as the market leader. The larger farmers started the use of tractor, power tiller etc. earlier than the small farmers.

12. Prevalence of tenancy was considered as another factor restricting mechanization of agriculture. It was found almost all the tenant farmers used machines--machinery. The emergence of the leased market of services of tractor, power tiller etc. has reduced the number of tenant farmers in the state. As tractor, power tillers are available on hiring basis, the farmer have started doing agriculture who originally leased out its land to other farmers. The existing tenant farmers used tractors-power tiller for ploughing the leased in land. Now, the terms of lease in and out is changing from the 50:50 basis to fixed amount basis.

13. Mechanization is found to be high among the educated farmers and families with educated children. Use of tractor, power tiller etc. is found to more among the educated farm families. The educated ones understand the benefits of transformation of technology. Such farm families want relieve of drudgery of physical labor by the use of machine- machinery in agriculture. This is found as one of the important points in favor of mechanization of agriculture.

14. The number of farmers who held negative or indifferent attitude towards the new technology was found very small in the whole sample.

15. The question of displacement of labor because of use of machine-machinery in a labor surplus country like India is the main argument raised against the mechanization. It is found the mechanization of agriculture in the state will compensate the labor displacement effect by income effect.

3.2. Modern machineries used in five surveyed circles

Table- 1: Modern agricultural equipments operating in five circles

Circle	Tractor			Power tiller			Thresher	Shallow tube well	LLP
	Govt. supply	Own	Total	Govt. supply	Own	Total			
Bongshor	36	15	51	14	12	24	0	1345	20
Furkating	16	26	42	62	199	261	0	143	150
Bhurbandha	10	14	24	20	13	33	14	1232	8
Dumunichowki	18	6	24	12	8	20	0	900	12
Silchar	7	5	12	52	10	62	0	13	26
Total	87	66	153	160	242	400	14	3633	216

Source: ADOs of Bongshor, Furkating, Bhurbandha, Dumunichowki and Silchar circles.

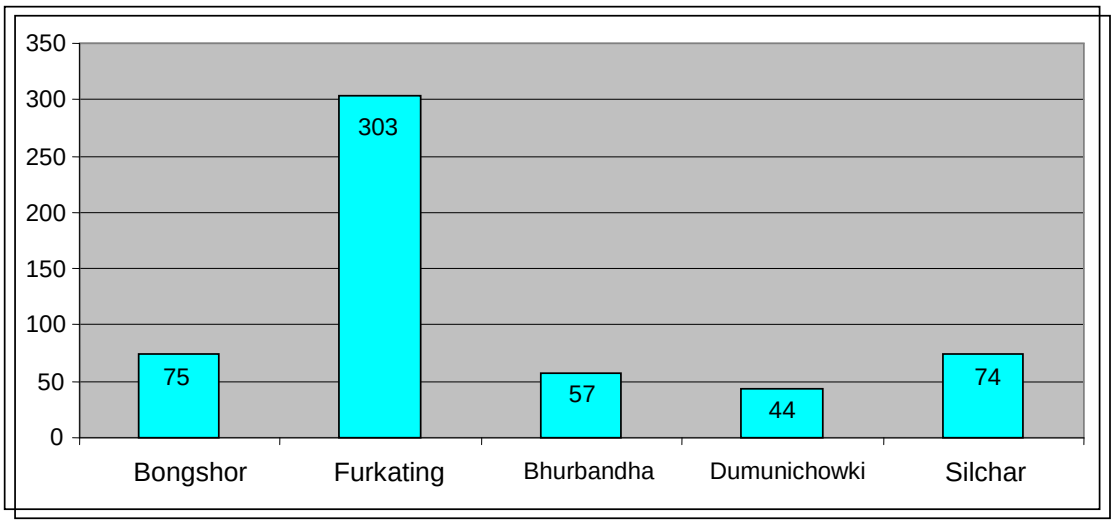

Fig. 1- Presence of tractor and power tiller (combined) in five circles

A picture of improvement in the use of agricultural machinery in five circles is given in the **Table-1** and **Fig. 1**. In the tillage and threshing stage use of machine is increasing significantly. The data presented in the table indicates that in five circles there are 153 tractors, 400 power tillers, 3633 shallow tube wells, 216 LLP/ water pumps and 14 numbers of threshers in the agricultural operation. In respect of tractor, Bongshor and Furkating circles are well ahead of the other circles. If tractor and power tiller are combined together the position of Furkating circle is far better than the other circles. All the threshers are used in Bhurbandha circle only. Highest numbers of shallow tube well are found in Bongshor and Bhurbandha. Position of Furkating is also better in case of LLP. Dumunichowki circle reveals a low position in respect of all the machineries. In all the circles the tractors and power tillers are found to be used for own ploughing, rented ploughing, transporting goods, threshing and carrying land.

3.3. Use of machine in Ploughing

In the primary tillage stage, use of machine is found to be increasing in the state. Use of tractor and power tiller is going along with the indigenous plough. Of course mechanization of agriculture in Assam can be regarded as tractorisation, as tractor is the only machine which is used mainly by the farmers in the state. The number of farmers adopting mechanized ploughing in the surveyed circles is shown in the **Table-2**. In the five surveyed circles, out of 224 sample farmers 8% have own tractor, 6 % have own power tiller and all most all the farmers use either tractor or power tiller or both tractor and power tiller for ploughing. Data collected in the field

survey shows that out of 224 sample farmers 11 % use both tractor and power tiller for ploughing. Out of that 224 sample farmers 37% do ploughing by tractor along with indigenous wooden plough. Again, 11% have used power tiller for ploughing along with indigenous plough. Interestingly 28% farmers have used both tractor and power tiller along with indigenous plough. The table indicates that majority of the farmers use tractor and power tiller along with the indigenous plough.

The use of individual tractor in the primary tillage is highest among the farmers in Bongshor, then in Bhurbandha, Dumunichowki and Silchar. Power tiller's use is highest in Furkating, then in Dumunichowki and Bhurbandha. Joint use of tractor and power is highest in Furkating, then in Bhurbandha and Bongshor. Use of tractor with animal drawn indigenous wooden plough is highest in Bongshor and Dumunichowki. Use of power tiller with animal drawn indigenous wooden plough is highest in Furkating and Silchar. Use of tractor and power tiller along with the animal drawn indigenous plough is highest in Silchar, then in Dumunichowki and Bhurbandha.

Table-2: Number and percentage of adopter of machine in tillage

Circle		**Tractor**	**Power tiller**	**Both Tractor &power tiller**	**Animal drawn plough & tractor**	**Animal drawn plough & power tiller**	**Animal drawn plough, tractor & power tiller**
Bongshor	Number	5	2	6	34	2	4
	Percent	9.43	3.77	11.32	64.15	3.77	7.54
Furkating	Number	2	6	7	3	16	5
	Percent	5.12	15.38	17.94	7.69	41.02	12.82
Bhurbandha	Number	4	2	23	0	7	10
	Percent	8.69	4.34	50	0	15.21	21.73
Dumunichowki	Number	4	3	20	4	3	19
	Percent	7.54	5.66	37.73	7.54	5.66	35.84
Silchar	Number	2	1	1	2	3	24
	Percent	6.06	3.03	3.03	6.06	9.09	72.72
Total	Number	17	14	24	82	25	62
	Percent	7.58	6.25	10.71	36.60	11.16	27.67

Source: field study

From the table, it is found that farmers of Furkating use more tractor and power tiller and farmers of Silchar use less number of tractor and power tiller in ploughing. In Furkating 21% and in Silchar 9% of the sample farmers use tractors and power tillers in ploughing. In the other three circles i.e. in Bongshor, Bhurbandha and Dumunichowki 13% of the sample farmers are found to be using tractor and power tiller in ploughing (as shown in **Fig. 2**). In the traditional style, animal drawn wooden plough is used for ploughing. In the field study it is found that the farmers having bullocks are also using the tractor, power tiller etc.

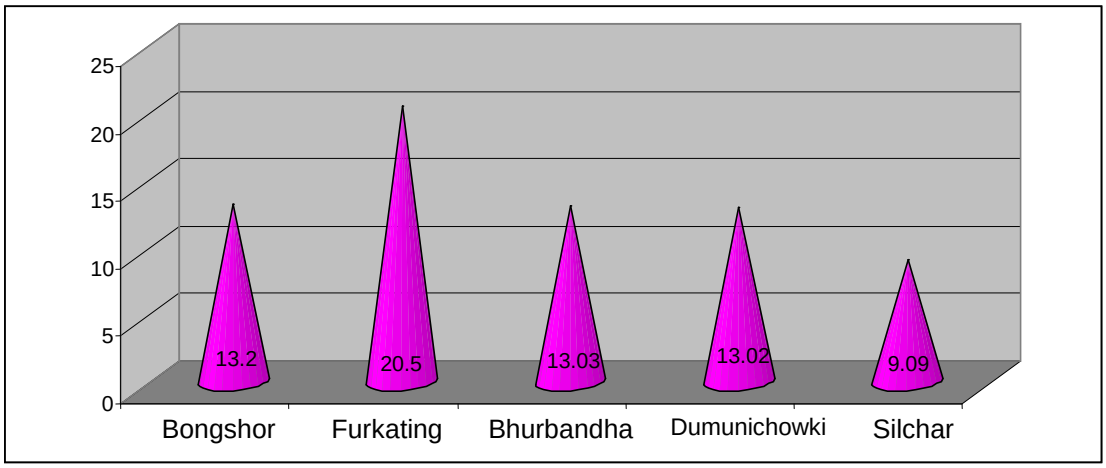

Fig. 2- Percentage of adopter of only machine in tillage in five circles

The **Table-3** indicates that out of 104 farmers those who have bullock 86% are found to be using tractor and 50% farmers have used power tiller (as shown in **Fig.3**). In case of irrigation, 100% bullock owners have used machines.

Table-3: Use of machine by bullock owner

Whether bullock is there	**Whether used tractor**			**Whether used power tiller**			**Whether used irrigational machines**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
Yes	90 (86)	14 (14)	104 (100)	52 (50)	52 (50)	104 (100)	104 (100)	0 0	104 (100)
No	102 (85)	18 (15)	120 (100)	69 (57)	51 (43)	120 (100)	119 (99)	1 (1)	120 (100)
Total	192 (86)	32 (14)	224 (100)	121 (54)	103 (46)	224 (100)	223 (99)	1 (1)	224 (100)

Source: field study * Figures in the parenthesis indicate the percentage of the total adopters

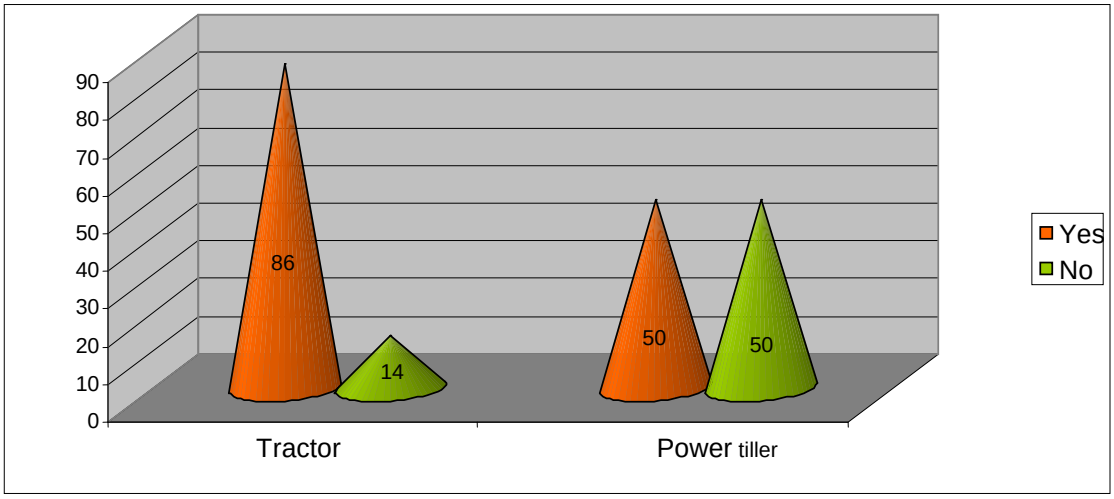

Fig. 3- Use of tractor and power tiller by bullock owner (in %)

3.4. Use of machine in Irrigation

The **Table-4** gives the information about irrigational practices in the five surveyed circles. In the surveyed circles, irrigation water is harnessed mostly by shallow tube well. 46% of the samples are found to be availed water through shallow tube well and 2% of the sample farmers get irrigation through diesel pump (as shown in **Fig.4**). All total 33% of sample farmers get the irrigation facility with the government support and 20% get at own cost. The IC engine driven centrifugal pump is an improved technique of irrigation. In Bongshor circle out of 53 farmers 79% have shallow tube well whereas in Bhurbandha out of 46 farmers 57%, in Dumunichowki out of 53 farmers 51% have shallow tube well for irrigation.

Table-4: Distribution of sample farmers by types of irrigation

Circle		**Major**	**Shallow tube well**	**Water Pump**	**None**	**Shallow and deep tube well**	**Total**
Bongshor	Number	0	42	0	7	4	53
	Percent	0	79.25	0	13.21	7.55	100
Furkating	Number	0	7	3	29	0	39
	Percent	0	17.95	7.69	74.36	0	100
Dumuni	Number	1	26	0	19	0	46

chowki	Percent	2.17	56.52	0	41.30	0	100
Bhurbandha	Number	0	27	0	26	0	53
	Percent	0	50.94	0	49.06	0	100
Silchar	Number	0	0	2	31	0	33
	Percent	0	0	6.06	93.94	0	100
Total	Number	1	102	5	112	4	224
	Percent	0.45	45.54	2.23	50	1.79	100

Source: field study

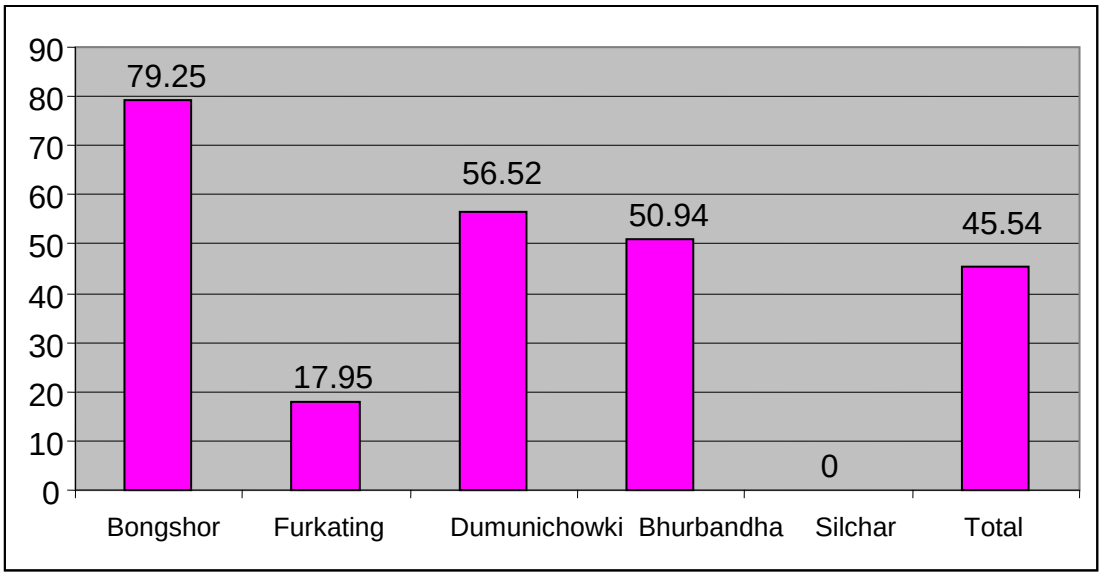

Fig. 4- Sample farmers (in percent) having shallow tube facilities

In Furkating and Silchar circles shallow tube well and other irrigational machines are not available. As the land in the Furkating circle is low lying farmers don't have demand for shallow tube well. Here the farmers use diesel pumps to irrigate water from the ponds and low lying places. In Silchar irrigational facility is absent although there is a high demand for it.

3.5. Modern machineries used in other pre harvesting works

Table-5: Distribution of sample farmers by leveling/Puddling/bund making /sowing type

Circle		Leveling (indigenous leveler)	Leveling (disc harrow)	Puddling (manual)	Bund making (manual)	Sowing (manual)
Bongshor	Number	52	1	53	53	53
	Percent	98.11	1.88	100	100	100
Furkating	Number	39	0	39	39	39
	Percent	100	0	100	100	100
Dumuni chowki	Number	46	0	46	46	46
	Percent	100	0	100	100	100
Bhurbandha	Number	53	0	53	53	53
	Percent	100	0	100	100	100
Silchar	Number	33	0	33	33	33
	Percent	100	0	100	100	100
Total	Number	223	1	224	224	224
	Percent	99.55	0.44	100	100	100

Source: field study

The **Table-5** gives the information about the use of machine in other pre harvesting activities like leveling/harrowing, pudding, bund making, sowing etc. Leveling and harrowing is still going in the manual way. Out of 224 sample farmers only 1 farmer is found to be using disc harrow for this activity. Remaining 223 farmers level their field manually. Puddling is another stage where improved practices are absent. In this stage 100% farmers do puddling manually i.e. by indigenous plough. Bund making is totally manual activity among farmers in the surveyed areas. Farmers use spade for bund making. Bund making machine has no use among the farmers. In the five circles there is no single farmer practicing any improved technique like sowing machine and seed drill in the stage of sowing and seedling. There is no use of any improved techniques for sowing and seedling among the farmers in the five circles. These works are done totally in the manual way. Although 100% farmers of the surveyed area use fertilizer- either chemical or organic the technique used for applying fertilizer is purely manual. Fertilizer can be used by leveler but there is no use of leveler among the farmers. For plant protection also

farmers use manual spraying. Manual knapsack sprayer is used by the farmers which can of course be considered as an improvised way. There is no case of use of sprayer and duster. For weeding there are improved techniques like Khurpi and Japanese wet land paddy weeder but no single case of using these techniques was found in the surveyed circles. Farmers in the five circles do weeding manually.

The **Table-6** thus shows that there is no case of using machines in the seedling, fertilizer use, and transplanting, and weeding activities in agricultural fields. These works are going in the manual way among the farmers of the state. Only in the spraying spray machine is used by all the farmers. Transplanting, particularly of paddy is purely manual operation in the surveyed area. Although improved technique like transplanter and self propelled paddy transplanter are there, only 1 farmer in Dumunichowki was found to be practicing transplanter and remaining 223 farmers of the five circles are found to be using manual way i.e. manual placement of seedling.

Table -6: Sample farmers by seedling/fertilizer use/Transplanting/weeding/spraying type

Circle		Seedling (manual)	Fertilizer use (manual)	Transplanting (Manual placement)	Weeding (manual Hand picking)	Spraying (Manual knapsack)
Bongshor	Number	53	53	53	53	53
	Percent	100	100	100	100	100
Furkating	Number	39	39	39	39	39
	Percent	100	100	100	100	100
Bhurbandha	Number	46	46	46	46	46
	Percent	100	100	100	100	100
Dumunichowki	Number	53	53	52	53	53
	Percent	100	100	98.11	100	100
Silchar	Number	33	33	33	33	33
	Percent	100	100	100	100	100
Total	Number	224	224	223	224	224
	Percent	100	100	99.55	100	100

Source: field study

3.6. Use of machine in harvesting and post harvesting works

Harvesting is one important stage where improved technique could be used. Already proven and used techniques of harvesting are power tiller drawn reaper harvester, tractor drawn reaper harvester and self propelled reaper harvester. The manual way is cutting by sickle. In the surveyed areas, although power tillers and tractors have been used by major portion of the farmers in primary tillage agricultural machines have not been used by the farmers in the stage of harvesting.

Table-7: Distribution of adopters according to the post-harvesting technology

Type		**Manual**	**Mechanised**
Harvesting	Number	224	0
	Percent	100	0
Threshing	Number	154	70
	Percent	68.75	31.25
Storing	Number	224	0
	Percent	100%	0
Transporting	Number	187	37
	Percent	83.48	16.52

Source: Field survey

The **Table-7** shows that 100% of the sample farmers follow the manual way of cutting i.e., cutting by sickle. Threshing is one stage of agriculture where tractors and power tillers have been used by the farmers to a great extent. In threshing both bullock power and power thresher are found to be practiced by the farmers in the surveyed areas. Those who have own tractor and power tiller mainly use these machines in threshing (as shown in **Fig. 5**).

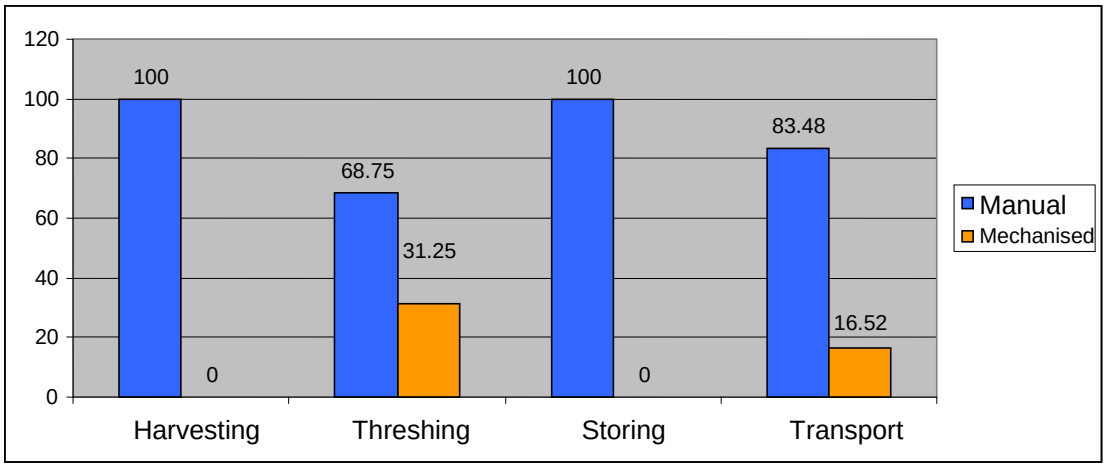

Fig. 5- Types of threshing work in five circles

The Table-8 shows that except Furkating in the other circles there is no case of threshing by hired tractor and power tiller.

Table-8: Distribution of sample farmers by threshing type

Circle		**Bullock treading**	**Power thresher**	**Both bullock treading & power thresher**	**Total**
Bongshor	Number	35	15	3	53
	Percent	66.03	28.30	5.66	100
Furkating	Number	10	29	0	39
	Percent	25.64	74.35	0	100
Bhurbandha	Number	41	5	0	46
	Percent	89.13	10.86	0	100
Dumunichowki	Number	41	12	0	53
	Percent	77.35	22.64	0	100
Silchar	Number	27	6	0	33
	Percent	81.81	18.18	0	100
Total	Number	154	67	3	224
	Percent	68.75	29.91	1.33	100

Source-Field Study

From the table it is found that out of 224 sample farmers 30% use power thresher and 69% use bullock power and only 1% are found to be using both bullock and power thresher for the threshing purposes. Significant point here is that the farmers having power tiller and tractor have used these machines for threshing purposes. Use of power tiller and tractor in threshing is highest in the Furkating circle. Here out of 39 sample farmers 74% use power tiller and tractor for threshing work. Next to Furkating in Bongshor and Dumunichowki farmers are found to be using power tiller and tractor in the threshing. In Bongshor 28% and in Dumunichowki 23% sample farmers are found to be practicing tractor and power tiller in threshing work.

Table-9: Distribution of sample farmers by transporting type

Circle		**Shoulder carriage and cart**	**Bullock cart**	**Power tiller trolley**	**Tractor Trolley**	**Four wheeler**	**Shoulder / Power trolley**
Bongshor	Number	40	1	2	10	0	0
	Percent	75.47	1.88	3.77	18.86	0	0
Furkating	Number	24	0	0	6	1	7
	Percent	61.53	0	0	15.38	2.56	17.94
Bhurbandha	Number	44	0	0	0	0	2
	Percent	95.65	0	0	0	0	4.34
Dumunichowki	Number	48	0	0	5	0	0
	Percent	90.56	0	0	9.43	0	0
Silchar	Number	31	0	0	2	0	0
	Percent	93.93	0	0	6.06	0	0
Total	Number	187	1	2	23	1	9
	Percent	83.48	0.44	0.89	10.26	0.44	4.01

Source-Field Study

In transportation stage also the use of machine is found to be present. The Table-9 shows that in the five surveyed circles five modes namely Shoulder carriage and cart, Bullock cart, Power tiller trolley, Tractor trolley and mini truck and small four wheelers are seen in the work of transportation of paddy and others. From the table it is found that in the surveyed circles out of 224 sample farmers 83% farmers practice manual way i.e. transporting by shoulder carriage

and cart. Only 1 farmer in Bongshor reported transporting through bullock cart. Interestingly out of 224 sample farmers 11% are found to be using power trolley and tractor trolley in transportation work. Out of 25 farmers those who use power trolley 23 reported using tractor trolley. It is seen that owner tractors have been used properly in the work of transporting. Out of 224 farmers 4% are found to be practicing both shoulder carriage and power trolley. There is no case of use of power trolley in Dumunichowki circle. From the table it is found that the use of power trolley in transporting is highest in Bongshor (23%) and Furkating (15%).The farmers of Bhurbandha circle don't use power trolley for this work and the use of power trolley is also very insignificant in Silchar circle. Storing is important stage in agriculture and scientific techniques have been developed for such work. But in the surveyed area the storing work practiced by the farmers is totally manual and no scientific way is found to be practiced.

3.7. Duration of machine in agriculture

Use of machine in agriculture is a recent practice among the farmers of Assam. The machines like tractor, power tiller, thresher, shallow tube well etc. have been used by the farmers in the agriculture fields of the state. The **Table-10** indicates that 70% of the sample farmers of the surveyed area have been using machines for last 4-6 years, 23% have been using for last 1-2 years, 4% for 7-9 years and 3% for 10-12 years and only 1 farmer for above 13 years. It is clear that majority of the farmers are using the machines for last 4/6 years.

Table-10: Distribution of sample farmers by years of use of machine in agriculture

Circle		**Bellow 3 yrs**	**4-6 years**	**7-9 yrs**	**10-12 yrs**	**13 and above**
Bongshor	Number	28	22	2	1	0
	Percent	52.83	41.50	3.77	1.88	0
Furkating	Number	5	27	2	4	1
	Percent	12.82	69.23	5.12	10.25	2.56
Bhurbandha	Number	1	43	2	0	0
	Percent	2.17	93.47	4.34	0	0
Dumuni chowki	Number	13	37	2	1	0
	Percent	24.52	69.81	3.77	1.88	0

Silchar	Number	5	28	0	0	0
	Percent	15.15	84.84	0	0	0
Total	Number	52	157	8	6	1
	Percent	23.21	70.08	3.57	2.67	0.44

Source: field study

The table further indicates that the practice of using machines in agriculture is older in Furkating than the other four circles. In Furkating 1 farmer is found to be using machine for more than 13 years and 4 farmers(i.e.10%) are using for 10-12 years. Here, 69% farmers are found to be using machine in agriculture for last 4-6 years. Next to Furkating the farmers of Bhurbandha are found to be using machines for longer period. In Bongshor and Dumunichowki the practice is about 4/5 years. In Silchar the practice of using machine by the farmers is found to be recent. Here no farmer is found to be using for more than 4-6 years. The interesting fact is that in all the circles use of machine is increasing.

3.8. Status of tractor and power tiller

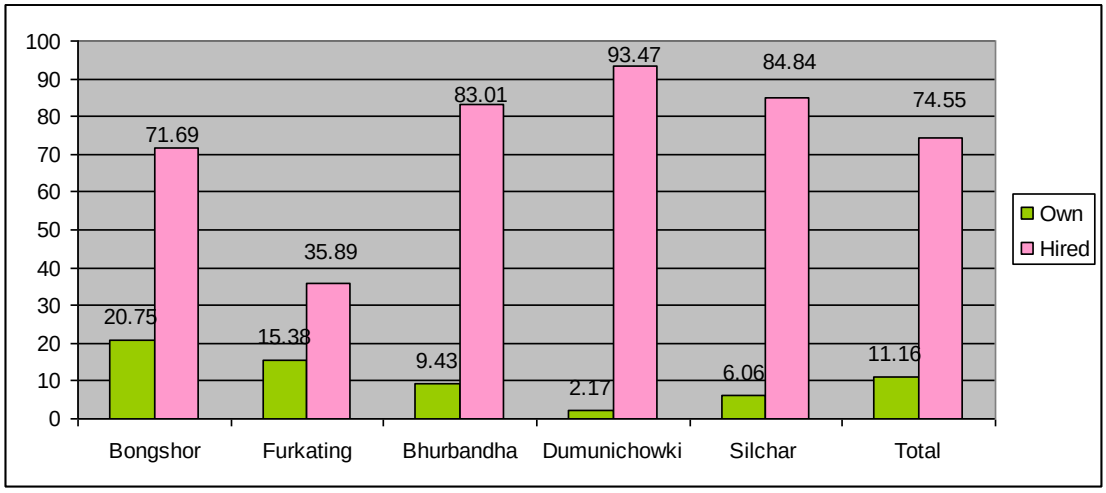

Fig. 6: Status of tractor in five circles

Fig.6 indicates that in Bongshor and Furkating circles more farmers use own tractor. Use of tractor in hiring basis is highest in Dumunichowki. Here, 93% of the sample farmers use hired tractor. Next to Dumunichowki circle in Silchar (85%), bhurbandha (83%) and Bongshor (72%) hired tractor is used by the farmers. In Bongshor and Furkating use of own power tiller is more.

Use of hired power tiller is highest in Silchar (73%), then in Furkating (44%) and Dumunichowki (42%).

3.9. Some Recommendations

Lele (2017) observed **"**For developing countries, advances in computing power, connectivity, artificial intelligence, biotechnology and GIS, and newer, more capable technologies hold tremendous promise. Inclusive agriculture, rural growth and structural transformation from agriculture to high-productivity manufacturing and other economic sectors can be accelerated, as technological change transforms individuals' lives and enables developing countries to progress at speeds and on scales previously inconceivable." The gap between skilled and unskilled labor has already widened and it has already posed a threat to the liberal world economic order in the form of anti-globalization movements. In this article, it was therefore said that to realize the positive outcomes of this new industrial revolution, public policymaking must bridge the already widening gap between skilled and unskilled labor.

The independent researcher found the case of India is salient because, unlike its East and Southeast Asian neighbors, rapid economic growth has not been inclusive enough to reduce the numbers of Indians living in poverty. As per World Bank report, India contains the largest number of poor people in the world: 270 Employment growths is critical in low-productivity agriculture, which accounts for nearly three-quarters of the poor population. But automation threatens to create more unemployment. Public policy must be directed toward increasing the productivity of poor people rather than just offering handouts.

The researcher found that despite technology's promise, there remains a need for substantial increase in old-fashioned investments to catch up with the backlog in physical infrastructure and education to achieve a geographically more dispersed development away from the 100 big cities. Around 25% of Indian adults cannot read or write, and the gender divide must be addressed with investment, particularly in rural women's education and training. Geographical application of new technologies is still limited in rural areas; many farmers remain unaware of these advances. Insufficient connectivity in rural areas along with a lack of basic computer knowledge and literacy hinder development. Substantial investment is needed in physical infrastructure, power,

broadband, transportation and education, particularly in rural regions and among the poorest populations in order to truly reap the benefits of the 4IR.

From the survey results following recommendations may be made for policy makers.

1. To educate the farmers about the benefits of the use of machines in agriculture, the agricultural extension network needs to be improved.
2. To expedite the process of transfer of technology, the existing system of communicating information to the farming community through the contact farmers has to be modified.
3. As the formal education of the farmers is less, knowledge of machine machineries can be given through electronic Medias like TV and Radio.
4. The agriculture department can provide trainings for providing proper knowledge of use of machine, which will also help in reducing the cost of mechanization.
5. The condition of supply of electricity to the agricultural fields needs to be developed.
6. To reduce the cost of mechanization, steps are to be taken for providing fuel at subsidized rate, supply of electricity to the agricultural fields.
7. Some young people can be given training of repairing and maintenance of the machines/ machineries with the help of necessary infrastructure so that local repairing centres are developed and cost is reduced.
8. For rapid expansion of mechanization the institutional credit is required to step up their active participation in providing loan for purchasing machines/machineries.
9. A proper policy is needed for the distribution of such machines/ machineries so that all the farmers get equal benefits.
10. As there is relation between mechanization and irrigation, irrigation facilities in the state have to be developed.
11. As the state lacks irrigation facility and it is regularly affected by flood strategy should be changed regarding selection of crops and its time of production.
12. For a new face of agriculture in the state it will also be necessary to develop the other infrastructures like proper marketing facility, storage of farm products and the network of distribution of agricultural inputs.

4. Conclusion

Agricultural growth has assumed new significance, as it has been realized, that even a high rate of industrial growth would not be sufficient to create adequate employment opportunities for the continuously expanding labor force of developing countries. To solve the problem of poverty and unemployment in these countries, the agricultural growth has been viewed as utmost necessity. The Indian agriculture thus has got renewed importance. A paradigm shift from being a part of problem it has become part of solution. In the context of global energy crisis and global climate change, Indian agriculture has opened a door of prospects. Inclusive growth and equity has got importance. Agriculture and heath is found linked. The opportunity is also there for new lines of commerce. The presence of a class of educated and young farmers in Assam and their inclination for use of modern method of farming is expected to change the traditional face of agriculture. Agricultural mechanization is expected to bring some social changes also in the state. Agriculture is the main base of the state is agriculture. The culture, traditions and the beliefs of people of the state is linked to its art of agriculture. So, it can be said that with the change of face of the agriculture sector, social changes in the state are obvious to come.

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