“AN STUDY ON THE STATUS OF AGRICULTURAL MECHANIZATION AND ITS NEED IN BUNDELKHAND REGION OF UTTAR PRADESH”

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ABSTRACT

Agriculture is the heart or backbone of a country because economy comes through it and needs a thrust. Recent surveys show that agricultural growth rate seems to be stagnant. With the introduction of agriculture in the world there were lot of problems so now the need to overcome those problems because the land were in a random form with no proper arrangements for sowing of crops. Nearly 65% of our country population depends upon agriculture as a source of their live hood and all over the world that in order to meet the food requirement of the growing population, rapid industrialization and modernization of agriculture are inescapable. In this work mechanization and timeliness of operation will be done by which better and prosperous agriculture will be obtained. At the time of starting of tilling of lands, the instruments used at that time were quite simple & all the instruments used were handmade or modified in some shape as per convenience. With the introduction of modern agriculture, lands were starting tilling in well definite shapes & forms. The implements used were tractors as well as other simple implements. The tractors tilled the lands followed by different kinds of plough and cut, invert or pulverized the soil & then beds were made on that land as per the requirement of crop. All these modifications come under the farm mechanization. Basically farm mechanization means the use of machines & technology in agriculture sector, the use of tractors, tube wells & plant protection measures are included in farm mechanization so in the farm mechanization the use of machinery is greater as compared to labour. In Farm mechanization the factors which will be considered are: Use of cultivable land, overcome of water problems, Timely operations, Labour problems, Electrification of Farms, Productivity enhancement, Land levelling & weed eradication. So in this work, proper farm machinery and tractor power will be selected for getting or enhancing the agricultural productivity by major crops grown.
CHAPTER-1
INTRODUCTION

Agriculture is the backbone of Indian economy and needs a thrust. Recent surveys show that agricultural growth rate seems to be stagnant. Agriculture has an immense effect on our GDP growth; about 22.1% of our GDP comes from agriculture. Nearly 65% of our country population depends upon agriculture as sources of their livelihood but after numerous Govt. Initiatives the result are not up to the mark. It is now realized all over the world that in order to meet the food requirement of the growing population, rapid industrialization and modernization of agriculture are inescapable. The package of modern technology includes the use of more efficient and economical farm implements and machines and suitable form of farm power. It has been observed that on most farms the production suffers because of delays in various agricultural operations. Thus the timeliness of operation is the essence of better and prosperous agriculture. “Agricultural mechanization embraces the operation of hand tools, implements and machines for agricultural land development, production, harvesting and on – farm processing. It includes three main power sources; human, animal, mechanical. Natural power (wind and water) has been included under mechanical power, since a mechanical devices is required to transfer this power into useful work. As a discipline, agricultural mechanization includes the manufacture, distribution and utilization of tools, implements and machines.”

Agriculture in India is unique in its characteristics, where over 250 different crops are cultivated in its varied agro-climatic regions, unlike 25 to 30 crops grown III many of the developed nations of the world. Moreover, the use of various sources of power from the humble arm of the farmer to the mightiest of tractors is ubiquitous. India is the largest producer of tractors in the world. The quantum of research outlay for the farming sector is a meager 0.86 % of the GDP as against 2-3 % in the developed world. In spite of this disparity, India has emerged as a net exporter of food grains and continues to forge ahead in the adoption and indigenization of many of the advanced technologies developed elsewhere in the world. In 1951, when the country was in its formative years after centuries of colonial rule, there were only 8635 tractors in use and all of them were imported. Production of tractors commenced during 1961-62, turning out 880 of them. This figure has peaked to over
262,000 in 1999-2000. The sale of tractors in 2003-2004 was 172,000. The quantum of power available for the farming sector rose from 45.29 million kW in 1971-1972 to over 170 million kW in 2000-2001. Correspondingly, power intensity on the Indian farm increased from 0.2 kW/ha to 1.30 kW/ha on the basis of net-cropped area.

The state of Punjab has the highest average farm-power intensity of 3.5 kW/ha and also has the highest productivity levels. During the same period, contribution of animate power reduced from 60% of the total farm power to less than 17% and mechanical and electrical power sources increased from 40% to over 83% It is also seen that the adoption of mechanical and electrical power was higher for stationary applications than for traction required for field operations. Power for traction (tractors and power tillers) increased from 8.46% to 32.85%, indicating that more and more power-operated equipment were coming into use. Human power continues to be a significant component for digging, clod breaking, sowing, intercultural, harvesting, threshing, cleaning, and grading for which traditional tools and implements have evolved over time in different parts of the country. The small and marginal farmers rely on draught animals for field operations, transport and agro-processing. The extent of area under the command of draught animals is about 57%. The need to achieve timeliness of field operations and effective utilization of inputs has resulted in the development of appropriate machinery, which also reduces drudgery.

Traditional tools and implements such as bullock-operated country plough, and bakhar for tillage, dufan or tifan, enatigoru and funnel and tube-attachment on country ploughs as sowing devices; sickles, khurpi, spades and a pad thresher for harvesting, digging and threshing; and swing basket, Persian wheel (rahat) and cradle pump for irrigation, etc. have been very popular in India. Use of electric or diesel engine-operated irrigation pumps, animal and tractor-operated cultivator and disc harrow for seed-bed preparation; seed drill or seedcum-fertilizer drill and planter for line sowing with fertilizer application; and mechanical power thresher and combine harvesters has also increased. Farmers have also adopted sprinkler-and drip-irrigation systems in commercial crops. Sun drying, winnowing, paddy hulling, pulse milling, oil expelling, wheat milling, pickle making, GUY and khandsari, ghee and khoa making etc. are the major processing activities undertaken by the farmers. The traditional processing equipment used by the farmers include supa, chalni, chakiya, fanta, silbatta, okhli, mathani, puffing pan, mini oil ghanis/kolhus, rice hullers and flour chakkis etc. High capacity modem machines introduced in urban and suburban areas for processing of agricultural produce have helped in increasing the income of the processors.
Use of wind and solar energy for winnowing and drying has been in vogue from times immemorial. India receives about 5x10^15 kWh/year solar energy, which can profitably be utilized for over 200 days in a year. The availability of solar photovoltaic devices has encouraged their use for water pumping and lighting. Several designs of cookers and water heaters are also available. Cooking needs of the villages are mostly met by the burning of biomass. Anaerobic fermentation of animal excreta for the generation of methane has attained considerable attention and several designs of biogas plants are in use. Biomass can also be gasified to obtain a combustible gas mixture mainly consisting of carbon monoxide and hydrogen in specially designed apparatus. This gas can be utilized for thermal applications and also for running engines. Cellulose based waste and non-edible oils of plant origin can be converted by bio-chemical processes to alcohol and esters for use in internal combustion engines to provide motive power and reduce the dependence on fossil fuels.

The manufacture of agricultural machinery in the country is carried out by village artisans, tiny units, small-scale industries and the State Agro-Industrial Development Corporations. Production of tractors, motors, engines and process equipment is the domain of the organized sector. The traditional artisans and small-scale industries rely upon own experience; user's feedback and government owned research and development institutions for technological support and operate from their backyards or on road side establishments without regular utility services. Medium and large-scale industries operate in their own premises with sound infrastructure, usually forming a part of an industrial estate, well-established manufacturing and marketing facilities and employ skilled manpower. Diesel engines, electric motors, irrigation pumps, sprayers and dusters, land development machinery, tractors, spare parts, power tillers, post harvest and processing machinery and dairy equipment are produced in this sector. They have professional marketing network of dealers and provide effective after sales service. They also have in-house research and development facilities or have joint ventures with advanced countries for technology upgradation.

Technology has a great impact on all aspects of economic life. It is inevitable and essential for accelerated development of under-developed countries. Infact, appropriate technology provides a valuable weapon in the war against poverty by making better use of available resources. This ultimately brings about prosperity for the entire population. In a nut-shell, technology promotes efficiency and satisfies human wants from scarce resources.

Technology is the body of knowledge, or the know-how, since the emergence of Green
Revolution the change that taken place in utilizing technical knowledge is known as technological change. It is concerned with a shift in production function which indicates the technical relations between output and inputs.

In other words, it is the application of scientific discovery of production and distribution which creates new products, new processes of manufacture and changes in the methods of distribution. Technological change provides greater output from resources of land, labour and capital. In this way, technology increases production with lower cost or better quality produce for the same cost. Technology can be defined in two senses. In its narrow sense, it deals with equipments and machines which are employed in production. In other words, it involves reproducible tangible wealth which can be used a number of times.

In a broader sense, technology includes not only reproducible tangible wealth but also body of the knowledge, skills, ideas that help the development and use of such machines and equipment. In the context of under-developed agriculture, this broad definition is of great significance. In short, technological change is expressed by capital, entrepreneurial skill, marginal land technical skill, a trained labour force and better utilization of labour, equipments and materials, improvement in the quality of resources, products and methods of production and nationalization of production process.

Technological change in agriculture comprises of introduction of high yielding variety of seeds, fertilizers, plant protection measures and irrigation. These changes in agricultural sector enhance the productivity per unit of land and bring about rapid increase in production. Technological change in agriculture can be classified into two

(i) Land augmenting technical change
(ii) Labour-augmenting technical change.

Land augmenting technical change involves change in biological techniques in crop production. It includes mainly HYV of seeds fertilizers, irrigation and plant protection measures. Labour-augmenting technical change includes mechanical changes, namely, rapid mechanization of agricultural operations, such as introduction of traders combine harvesters. This change in agricultural technology in India is regarded as “Green Revolution”. This is associated with the package of agricultural inputs and new agricultural practices. The package approach which includes, apart from HYV of seeds, fertilizers, inputs, weedicides, control over water supply, tractors etc. are the major feature of new agricultural technology.
Indian agriculture has witnessed significant changes in production technology through the introduction of high yielding varieties of crops, especially wheat and intensive application of complementary modern inputs in farming. The new momentum created by modern seeds and fertilizers was considered the initiation of Green Revolution. Consequently, the consumption of several agro-inputs like pesticides, growths regulating compounds and weedicides have increased, besides the fertilizers all over the country. It is accepted that consequent to the adoption of modern technology the farm production has increased considerably.

India is recognized, the world over, as a leader in the manufacture of agricultural equipment and machinery such as combine harvesters, plant protection equipment, drip irrigation and micro-sprinkler. Sizeable quantities of farm implements are exported to Africa, Middle East, Asia, South America and other countries. Directory of Agricultural Machinery and Manufacturers is an attempt to put together all relevant information regarding the availability of various implements for land development, seed bed preparation, seeing and planting, intercultural, plant protection, irrigation, harvesting and threshing and post harvest operations. It also covers many of the renewable energy technologies available in the country for the use of the average farmer or the farming community. It provides information on various types of tools, implements and equipment used in production agriculture and processing. Information on each item contains a brief description of its construction, broad specifications, its uses and power source required. At the end of each item, its source of availability has been provided for ready reference.

1.2 SCOPE OF MECHANIZATION

It is quite true that the farmers of developing countries have the lowest earnings per capita because of the low yield per hectare they get from their land holdings. One of the few important means of increasing farm production per hectare is to mechanize it. Mechanization may have to be done at various levels. Broadly, it can be done in three different ways:

I. By introducing the improved agricultural implements on small size holdings to be operated by bullocks

II. By using the small tractors, tractor-drawn machines and power tillers on medium holdings to supplement existing sources.
III. By using the large size tractors and machines on the remaining holdings to supplement animal power source.

As a matter of fact, the progress of the country should be mainly judged on the basis of degree of farm mechanization (production per worker and the horsepower under his command per unit area).

Large amount of labour or draft power, which can be replaced through machines, provides a strong incentive to mechanize.

From the energy application point of view, the Indian agriculture is in the transition from:

Stage 1 (Human Power) and Stage 2 (Animal Power)

Stage 3 and 4 (Power tiller or four wheel tractor).

The main objective of this work is to increase the mechanization for the farmers of Bundelkhand region of Uttar Pradesh by which cropping will be increased. It will be similar to the concept of just in time because the concept of just in time define the right product should be produced at right time and in right quantity so when the proper cropping system will be used then neither the farmers of Bundelkhand region will face the problem of less production nor the problem of cropping. So first this work will solve the problem of cropping. This work will also identify the mechanization gap in different farm operations which will also increase the major crops in the same region. As the concept of Just in time consist of some assumption and some strategies also soon the same concept this work will also develop or can say suggest strategies for mechanization of Bundelkhand region for enhancing the agricultural productivity. For the proper selection of farm machinery available in different form like tractor power etc., the selection of optimum size of Farm Machinery is necessary so this work will also develop a model for the same purpose.

1.3 PROBLEM FORMULATION:

For instance, the sowing of wheat in Punjab is done up to the first fortnight of November. A delay beyond this period by every one week leads to about 1.50 Quintals per acre decrease in the yield. This is also correct in the case of other crops and for other farm operations like hoeing, irrigation, harvesting, threshing and marketing which needs to be performed at appropriate time otherwise the yield and farm income is affected adversely.
OBJECTIVES:

i) To assess the present status of mechanization and practices followed by the farmers of Bundelkhand region of Uttar Pradesh for major cropping systems.

ii) To identify mechanization gap in different farm operations for the major crops in Bundelkhand region of U.P.

iii) To suggest the strategies for mechanization of Bundelkhand region for enhancing agricultural productivity.

iv) To develop a model for selection of optimum size of farm machinery and tractor power and validate it with the help of collected data.
CHAPTER-2

REVIEW AND LITERATURE

This chapter compiles the work done by several authors on the status of mechanization with reference to the intensity of power or energy availability, and its impact in increasing the agricultural and labour productivity.

2.1- Technological Changes in agriculture system
2.2- Growth of farm mechanization in India and World
2.3- Status of Farm Mechanization
2.4- Effect of farm mechanization on the agriculture system
2.5- Growth of Farm Mechanization in Uttar Pradesh
2.6- Constraints of farm mechanization
2.7- Environmental study of Bundelkhand Region.

2.1 Technological Changes in Agriculture System.

Srivastava et al. (1975) stated that the technological innovations in agriculture can be divided into two broad types, viz., Biological and Mechanical. Biological innovations refer mainly to inputs that increase the productivity of a given land base. High yielding plant varieties and fertilizer are the examples. Biological innovations are found to raise total farm cost. Mechanical innovations mainly are those that Cause a reduction in total costs, while biological innovations are labour saving. Green revolution is frequently described as a seed-fertilizer technology. In a sense it falls in the class of biological innovations.

Bisaliah (1977) decomposed the growth per acre wheat output in Punjab into its sources. He found that technical change contributed 15 per cent and increase in the use of labour, fertilizer and capital per acre under Mexican wheat contributed about 25.5 per cent to increased output (40.5 per cent). Individual contribution of labour, fertilizer and capital were 2 per cent, 15 per cent and 8 per cent respectively.

Kunnal (1978) studied the effect of introduction of new jowar technology on output growth in Hubli taluk of Karnataka state by using output decomposition model. He observed that a new technology farm produced about 72 per cent more output than an old technology farm of
which, 33 per cent was due to technical change and 38 per cent was due to the increase in input levels.

**Kumar and Singh (1980)** attempted to examine how much of the growth in milk yield was due to technological change i.e., breed and how much of it was due to increased quantity of feeds and fodder. The incremental contribution of each explanatory variable, namely feed and lagged milk production revealed that feed nutrients contributed 3 per cent for crossbred cows, 2 per cent for “Sahiwala” cows. The lagged milk production contributed 47 per cent and 27 per cent in the total variation in milk yield for crossbred cows and “Sahiwala” cows respectively. The contribution of technological change to the total change in milk production was estimated to be 36 per cent. An increased use of feed inputs for crossbred cow contributed about 34 per cent to the total change in milk yield.

**Alshi (1981)** studied the impact of technical change on output in cotton economy in Akola district of Maharashtra state. The per hectare production on American cotton and hybrid cotton farms was more by 43 per cent and 306 per cent than the desi cotton farms. The contribution of technical change to this output growth was 27.77 per cent and 110.57 per cent, respectively. Increased use of labour, fertilizer, FYM and capital per hectare contributed 16.4 per cent in American cotton and 199.87 per cent in hybrid cotton. Among the various inputs, capital turn out to be an important source of output growth.

**Gundu Rao et al., (1985)** fitted the Cobb-Douglas production function to ragi data on both local and improved varieties in Bangalore. The authors found out a positive productivity differential (14 per cent), which emerged with the introduction of transplanting method into broadcasting local variety of ragi. About 45 per cent positive productivity differential has been generated with the introduction of new varieties of ragi to local variety farms, following the transplanting method. New technology (improved variety of ragi) contributed about 32 per cent more output over the local technology (TLV). Another dominant factor to the productivity differential (15 per cent) has been identified to be capital.

**Umesh and Bisaliah (1987)** using output decomposition model examined the impact of technical change in paddy production in Karnataka. They observed that HYV paddy variety Sona masuri yielded 34 per cent more than masuri variety, of which technical change contributed 17 per cent and increased input levels of labour and plant nutrients contributed 17 per cent.
Suligavi (1988) examined the impact of technological change in rainfed cotton in Dharwad district using output decomposition model. He observed that hybrid DCH-32 cotton variety (new technology) produced 115 per cent more output per farm than local cotton variety Jayadhar (old technology). To the 115 per cent more output, new technology contributed 82 per cent and increased level of inputs contributed 35 per cent. The individual input contribution of seed plus fertilizer was 19 per cent, plant protection chemicals 3 per cent and capital 13 per cent. The results indicated that the technical change was a major source of output growth in cotton technology.

Hiremath (1989) employed the Cobb-Douglas production function through restricted UOP profit function with constant returns to scale. The structural break was observed (Chow test) in A-2 and A-119 bidi tobacco varieties (new technology) over S-20 (old technology). The estimated total growth in output of A-2 over S-20 was 105 per cent of which, the contribution due to technical change was 72 per cent and of total inputs was 33 per cent. The estimated total growth in output of A-119 over S-20 was higher by 154 per cent, to which technical change contributed 90 per cent and changes in the level of inputs contributed 64 per cent. In both technologies the new seed technology, fertilizer and labour were identified as the major sources of growth in tobacco output.

Lalwani (1989) studied the impact of technological change on Dairy farming sector in India under the Operation Research Project (ORP) of the National Dairy Research Institute (NDRI) with an objective of decomposing the output gain in milk yield occurring as a result of shift in dairy technology. It was found that the adoption of milch cross breed cattle, brought about upward shift in the threshold level of milk yield, enabling the farmers to get more milk at the existing levels of input use. However due to negative contribution of non-neutral variant of technological efficiency, the dairy farmers failed in consolidating such technological gains as they were unable to adjust to the new requirement of the cross breed dairy technology.

Hiremath and Murthy (1991) studied the impact of technical change on factor shares in the production of beedi tobacco in Karnataka. They found that the actual factor shares under old technology variety S20 for land, labour, fertilizer, capital and manure were 0.5641, 0.01708, 0.0511, 0.1360 and 0.0437, respectively. They were not significantly different from the estimated factor shares of the corresponding factors which implied that all the inputs were paid their due share under old technology. Similar pattern was evident under new technology.
varieties like A-2 and A-119. Per acre absolute actual income has increased by 78% and 204% under new technology varieties (A-2 and A-19).

**Suligavi and Murthy (1991)** studied the impact of technological change on employment and production relationship in cotton in Dharwad district, Karnataka. The study was based on a stratified random sample of 135 farms of which 72 farmers grew high yielding varieties (HYVs) and 63 farmers grew local cotton. It was observed that the input and output mean levels differed significantly between technology levels. The HYV technology was better by as many as three times as that of local technology. The new technology was not only high yielding, but also input use intensive in respect of inputs.

**Pookpakdi (1992)** observed that Green Revolution made a notable contribution to raising the production of rice and wheat by small-scale farmers, particularly in Asia and the Pacific. The high-yielding varieties (HYVs) of rice released in the 1960s increased the productivity of rice by about 70% and of wheat by 150%. The HYVs are responsive to very high applications of fertilizer, and are efficient producers under intensive management conditions (RAPA 1989). One indirect effect of the Green Revolution was to reduce the output of protein-rich grains and pulses which contributed greatly to ensuring a balanced diet for the rural poor (FAO 1991b). These crops were no longer competitive in terms of financial returns per hectare. The Green Revolution has also raised several sustainability issues.

**Deoghare (1993)** used the Cobb-Douglas production function through restricted UOP profit function with constant returns to scale studied the effects of technical change in cotton crop in Maharashtra state during 1989-90. The structural break was observed in LRA 5166, H-4 and AHH 468 cotton hybrids (new technology) over AKH 4 (old technology). The estimated total growth in output of LRA 5166, H-4 and AHH 468 over AKH 4 was 69.52 per cent, 60.37 per cent and 103.97 per cent respectively. The contribution due to technical change was 40.24 per cent, 22.02 per cent and 51.89 per cent respectively for the above cotton hybrids. The total change due to human labour, bullock labour, fertilizer and capital inputs was 29.28 per cent, 38.37 per cent and 52.08 per cent for LRA 5166, H-4 and AHH 468 over AKH 4 cotton variety respectively.

**Thakur and Sinha (1994)** examined the impact of technical change in rice production in Bihar agriculture. He observed that the contribution of new rice production technology is more pronounced in southern region as compared to northern region of the state. New rice
production technology produced 43.47 per cent and 47.77 per cent higher yield in northern and southern regions, respectively. The technological bias with respect to factor inputs in rice production was estimated as land and labour saving as well as fertilizer and capital using in northern region. Whereas, it was estimated as labour saving as well as fertilizer and capital using and land saving in southern region.

**Sharma and Singh (1995)** analyzed the impact of technological change on investment pattern and resource structure in Kangra and Kullu districts of Himachal Pradesh. The investment in capital assets for productive purpose increased with the farm size. The average investment per farm in crop farming in case of adopted farmers was Rs. 17,571.53, Rs. 17,699.21 and Rs. 23,716.99 on small, medium and large categories, respectively. Where as in case of non-adopted farmers, it was Rs. 7,867.36, Rs. 8,262.28 and Rs. 12,275.40 on small, medium and large categories. The study pointed out that due to implementation of various development programmes, the investment on productive assets, cropping intensity and productivity increased more on adopted group of farmers. The study also revealed that adoption of new technology i.e. growing of high yielding varieties was significantly and positively related to farm size, education level of farmer, availability of family labour and technical knowledge.

On measuring the sources of output growth in new milk production technology, **Gaddi and Kunal (1996)** opined that, the total growth in milk yield per cow per lactation, by shifting to new production technology was about 145 per cent. However the estimated growth in milk output was 146 per cent of which 47 per cent was contributed by new milk production technology with the existing level of inputs. The contribution of increased level of inputs was 99 per cent. Among the inputs, the contribution of feed (40 per cent) was the highest, followed by labour (26 per cent), fodder (21 per cent) and capital (12 per cent).

**Mattigatti and Iyengar (1997)** conducted a study to evaluate and compare the resource use efficiencies on sericulture and non-sericulture farms in the Hassan district of Karnataka. The results revealed that both sericulture and non-sericulture farms had significantly different production functions. Sericulture farms used less fertilizers and a higher amount of farmyard manure (FYM). Labour had a significant contribution in the case of sericulture farms and gave more scope for additional use of labour. Non-sericulture farms inefficiently used the labour. The gross profit of sericulture farms (Rs. 5,981.16 per acre) was comparatively higher than that of the non-sericulture farms (Rs. 4,066.62 per acre). The neutral technological
efficiency for sericulture farms was 25.46% more than for non-sericulture farms. Labour (92.69%) and chemicals (18.44%) while fertilizers indicated the non-neutral technological efficiency more and FYM showed technological inefficiency. The overall non-neutral technological efficiency was positive (7.28%). The gain in gross profits of sericulture farms as a result of change in quantity of input use was comparatively less i.e. 5.84%, out of which FYM contributed 6.45% and labour 2.29 %, respectively. Other inputs like fertilizers and chemicals contributed negatively. The total gain in gross profits of sericulture farms was 38.58% more than that of non-sericulture farms per acre.

**Kumar and Singh (1999)** made an attempt to evaluate the effect of change in rice production technology on functional income distribution and determine the extent of change in the effects of factor specific technical bias on functional income distribution. The results revealed that the new agricultural technology introduced in Manipur was biased towards the more use of labour and fertilizer and the saving of pesticide and insecticide in own holdings. Technical bias with respect to land was neutral and its estimated factor share remained unaltered under new technology.

**Badal and Singh (2001)** studied the technological change in maize production in Samastipur, Vaishali and Hazaribagh districts in Bihar. A test of structural break between production functions for local varietal technology and high yielding varietal technology of maize revealed that shift in production function of HYV technology was due to change in slope as well as shift in the intercept, implying thereby the existence of neutral as well as non-neutral technological change. The total differences in the productivities per hectare between local or traditional varieties and HYVs of maize were estimated to be 69 per cent in kharif and 80 per cent in rabi.

**Kunnal et al., (2002)** studied that the impact of new technology on output, factor shares and employment in bengalgram production in Karnataka. Growing of high yielding varieties of bengalgram (technical change) resulted in about 25 per cent of additional output. To this increased output, the technology (HYV) component accounted for 10.76 per cent, while increased use of inputs accounted for 14 per cent. All the inputs stood to gain with the introduction of new technology in Bengal gram production.

**Mattigatti et al., (2002)** evaluated the technological change in the management of small-scale to large-scale irrigated sericulture farming by employing Cobb-Douglas production
function and the technological decomposition model. The technological gap between different scales of farming was found to be significant. The shifts in technology from small-scale to medium-scale and medium-scale to large-scale have proved their efficiency in attaining higher profitability with 54.96% and 82.97% efficiency, respectively. The shift from small-scale to large-scale ultimately proved efficiency to the extent of 137.93%.

Kumar (2003) measured the technological change in dairy farming in Tamil Nadu with the view to formulate some guidelines for increasing the growth in milk production. The total gain in per day milk yield due to shift in technology was found to be 44.42 per cent, of which, 36.55 per cent occurred due to technological change and 7.82 per cent was due to the difference in the level of input use.

Kumaresan et al. (2005) studied the nature of technological changes in silk cocoon production through the measurement of productivity differences between new bivoltine sericulture (CSR hybrid) technologies and the conventional multivoltine sericulture (Cross Breed) technologies and analyzed the constituent sources of such differences. The production function analysis indicated that farm yard manure, chemical fertilizer and cocoon feed ratio were the important variables that significantly influenced the CSR hybrid cocoon production. The total gain in cocoon production due to the shift from cross breed to CSR hybrid was found to be 35.22 per cent, which was mainly due to the difference in the levels of input use. The results indicated the adoption of CSR hybrids in place of cross breeds would bring an upward shift in the cocoon yield. The positive contribution of neutral technological change (15.40 per cent) was offset by the negative contribution of non-neutral technological change (14.28 per cent) resulting in meager yield gain due to technological change. The yield gain due to changes in input use was significant with 34.10 per cent.

Kumar (2008) pointed out that the globalization agreement on Agriculture provides for new opportunities for increased international trade in Agriculture. Globalization was felt that the disciplines of GATT, which traditionally focused only on import access problems, should be extended to measure affecting trade is agriculture, including domestic agricultural policies and the subsidization of agricultural exports. It was felt necessary to reform agricultural policies in order to achieve trade liberalization in agriculture. The idea was to progressively reduce trade distorting subsidies, improve import access and curb export subsidies in agriculture. Under the agreement on Agriculture the main countries would have to reduce drastically subsidies granted to the farm sector.
Vanitha and Anitha (2008) stated that agriculture is the largest and most important sector of the Indian economy. But this sector remains most backward and about 40 per cent of rural population remain below the poverty line. Much of the rural population does not have access to common infrastructure like connectivity, electricity, health and safe drinking water. Complex characteristics of rural India include inaccessible terrain and dispersed villages, suboptimal utilization of natural resources, lack of extension of adequate privileges are detrimental to the socio-economic environment in India. Imbalance in socio-economic development and rural urban divide can be removed if the infrastructure in rural areas is made adequate, qualitative and a growth oriented business environment is created. This in turn can generate employment opportunities.

Basavaraja et al. (2008) studied the technological change in paddy production in Andhra Pradesh by comparing the profitability of SRI (System of Rice Intensification) method of rice cultivation with the traditional methods. The yield realized in traditional method was 6.07 tonnes per hectare, while it was 8.51 tonnes under SRI method. The production functions for SRI and traditional methods were also estimated separately. Using the decomposition model, the productivity difference between the SRI and traditional method was decomposed into its constituent sources.

Mohammed (2009) views that Reduction and especially, elimination of agrochemical require major changes in management to assure adequate plant nutrients and to control crop pests. As it was done a few decades ago, alternative sources of nutrients to maintain soil fertility include manures. Sewage sludge and other organic wastes, and legumes in cropping sequences. Rotation benefits are due to biologically fixed nitrogen and from the interruption of weed, disease and insect cycles. A livestock enterprise may be integrated with grain cropping to provide animal manures and to utilize better the forages produced. Maximum benefits of pasture integration can be realized when livestock, crops, animals and other farm resources are assembled in mixed and rotational designs to optimize production efficiency, nutrient cycling and crop protection.

Mohammed (2010) stated that in India is making a substantial surge in the GDP growth. We are contemplating a 10 per cent + increase with euphoria. Among the major sectors, namely, agriculture, manufacturing and services. The main GDP growth is due to manufacturing and services. In spite of the meagre 2.1 per cent growth in agriculture, we are still able to achieve a substantial increase in GDP largely because of manufacturing and services. Apart from
GDP growth, a populous nation like India which constitutes about 1/6th of the human race – has to think seriously about food security for its future. The food habits are also changing fast. In the past, the priority was to feed million of poor people at least one square meal a day. Today, the priorities are changing. More affluence, resulting out of the GDP growth, has paved the way for more successful people to look for variety and quantum, which has in turn increased the demand for supply of food.

2.2- Growth of farm mechanization in India and World

Sahota (1968) carried out the multi-dimensional analysis of resource allocation and concluded that there were few significant inefficiencies of resource allocation in Indian Agriculture. Farm management data covering three cross sections, eight farm size groups and six regions of India were used for this purpose. Along with the important inputs taken as explanatory variables, the year, size and region dummies were introduced in the regression equation with a view to account for the specific characteristics of individual units of the time periods and various cross sections.

Radhakrishna (1969) made the classification of a set of farmers into efficient and inefficient farmers on the bases of a number of efficiency norms through Discriminant Analysis. The issue of determination of efficient farmers arose in the context of formulation of a price policy for agricultural commodities which had to take into account, inter-alia, and the cost of production of crops. The determination of efficient farmers was attempted only as the basis of measures of economic efficiency. The data were obtained from the studies in the “Economics of farm management in Andhra Pradesh” and related to ninety three farmers who had grown irrigated paddy in the first season. The variables considered for determining efficient farmers were:

i. efficiency criteria namely yield of paddy per acre,

ii. Cost of production of paddy per maund (cost c); and

iii. The ratio of value of output to cost.

The Discriminant Analysis demarcated the farmers into efficient and inefficient ones. The average yield per acre and the average cost per unit of produce for all the ninety three farmers were calculated. Of these, whoever had the output-cost ratio more than unity was considered to be an efficient farmer?
Saini (1969) evaluated the efficiency with which farmers in the States of Uttar Pradesh and Punjab used their resources to achieve the highest net returns from crop production. The investigation showed that farmers were quite rational in terms of their response to economic opportunities and made adjustments in resources use. This rationality, however, did not imply that farmers always succeed in operating their farm business at economically optimum levels. The unexploited economic margins as indicated by the existence of an excess of marginal value product over factor costs in the two states suggested that farmers were not always efficient as allocators of resources in exploiting fully the economic opportunities available to them.

Ketkar (1975) determined the potential impact of new technology on Indian Agriculture through programming model. Any shortfall of actual output from program results was termed inefficiency. These were differentiated on the basis of amounts of N, P, K used as well as the use of irrigation and high yielding seeds in dry and wet season of the year 1968-69.

Singh and Kahlon (1975) examined the resources use efficiency on sample farms in the Central Plains of Punjab, comprising two general types of farming area viz. Non- Bet and Bet. The farmers were classified into different groups on the basis of source of irrigation and source of draught power. The production elasticity of land and human labour were positive and statistically significant in case of six out of eight farm classifications. The elasticity of production with respect to working expenses was the highest. The production elasticity of expenditure on irrigation, on bullock operated, tube well plus canal irrigated farms was positive, but that of expenditure on draught power was negative in the Non-Bet area. But because of large holdings in the Bet area, the elasticity of draught power was positive for bullock-operated, tube well irrigated farms. The analysis also indicated increasing returns to size as well as the rationality of resource use.

Chamak and Singh (1979) examined the resource use efficiency in Punjab Agriculture. They concluded that land, labour and working capital were the significant variables explaining changes in output. As regards fixed capital, its production elasticity was found to be negative but non-significant in all the cases. The marginal value product (MVP) of land was the highest on the small farms followed by the large and medium sized categories. The comparison of MVP of different factors with their respective factor costs indicated significant inefficiencies in resource use for almost all the input factors on all the farm categories and also on the overall farms.
Sharma and Tiwari (1985) studied eight villages along the embankment of river Sutlej. All the cultivators of the selected villages were stratified into categories ‘A’ (<1.5 ha) and ‘B’ (> 1.5 ha). On the category ‘A’ farms, the ratios of MVPs of human and bullock labour to their respective acquisition costs were found significantly less than unity and indicated the excessive use of these resources. In case of fertilizers and manures and expenditure on fixed assets, the ratios were significantly greater than unity implying that production on average farm of category ‘A’ could have been increased significantly by using more of these factors. Land and seed in this category had been used efficiently. On category ‘B’ farms, most of the ratios except bullock labour were not significantly different from one and hence indicated that these resources had been used efficiently. But the bullock labour was excessively used on category ‘B’ farms.

Moorti et al (1986) studied the locative efficiency of farm resources in Kangra district of Himachal Pradesh. They tried the production function for different enterprises on different sizes of farms, viz. marginal, small and large. Paddy and maize in the Kharif season and wheat and oilseeds in Rabi season were important crops in the study area. The higher cropping intensity on small farms showed more rational use of land on these farms. Expenditure on human labour per farm was the highest on all farms followed by bullock labour, F.Y.M, fertilizer and chemicals. The marginal farms were more human labour intensive than for other inputs. Returns to scale on different sized farms showed that productivity could be increased through additional use of inputs other than human labour.

Banerjee and Santra (1988) analyzed the farm size, productivity and resource use efficiency in agriculture of the Nadia district of West Bengal. The results from the regression model relating input to farm size demonstrated a decreasing intensity of input use per farm as the farm size increased. There was a positive correlation between farm size and productivity. However, the inverse relationship between farm size and productivity was not a confirmed phenomenon. It was observed that the elasticity of input use with respect to farm size was less than unity for each factor input. Further, the elasticity of labour use with respect to farm size was much higher than the elasticity of any other input with respect to farm size.

Lalwani (1990) studied the benefits from crossbreeding indigenous cows with exotic ones and also examined the allocative efficiency of resources in Karnal district of Haryana. Marginal physical products and the MVPs were derived from milk production functions for buffaloes, crossbred and indigenous cows for four farm size groups, viz landless, small (up to
2 ha), medium (2.01 to 8 ha) and large (above 8 ha). The dairy households with land made excessive use and those having no land made less use of green fodder. Concentrates were generally used deficiently; dry fodder use was excessive for indigenous cows. The human labour use for crossbred cows was excessive on landless and medium farm sizes but deficient for buffaloes and indigenous cows.

Grover et al (1992) examined the impact of farm mechanization on input-use efficiency in Bathinda district of Punjab. The analysis using the Cobb-Douglas function brought out that there was no marked difference in the resource use efficiency among the farms having different levels of mechanization. But, in a broader sense, the intensity of input use increased as the level of mechanization increased, particularly so in the case of human labour and fertilizers. The irrigation resource was found to be over-used on non-mechanized, partially mechanized with tube wells and fully mechanized farm situations. But, it was underused on partially mechanized farm with tractors but no tube wells. The MVP of irrigation (2.05) which was statistically significant indicated the possibility for increasing the expenditure on this category of farms. Also, the MVP of expenditure on insecticides and pesticides (3.66) on the partially mechanized farms turned out to be significant which implied that the expenditure on plant protection could profitably be enhanced.

Grover et al (1992) studied resource productivity of rapeseed and mustard in Punjab. The data were taken from the ‘Farm Management Study in Bathinda District of Punjab’ for the year 1987-88 by using the two-stages stratified random sampling design with village as the primary and operational holding as the ultimate unit of selection. The farm size groups were identified by pooling all the operational holdings raising Rabi oilseeds (rapeseed and mustard crops) in the sample villages. Three farm size-groups were thus identified and categorized into small (less than 5.97 ha), medium (5.97 to 12.25 ha) and large (12.25 ha and above) with an overall sample of 389 holdings. Regression analysis was employed to bring out the contribution of farm size and investment in human labour, bullock labour, manures and fertilizers, plant protection and irrigation to gross income from rapeseed and mustard. The findings showed that though the rapeseed and mustard crop competed favorably with the major crops of the region, yet it was more prone to insect-pests and diseases. It was also pointed out that plant protection was the most important factor which highly contributed to the gross income of the oilseed growers of all sizes of farms. Similarly, investment in human labour for producing rapeseed and mustard also had high potential for increasing returns.
Kaur and Singh (1992) examined the resource productivity and use-efficiency in agriculture across different agro-climatic zones of Punjab. The study indicated the prevalence of constant returns to scale in all the zones. The MVP for fertilizers was the highest in Zone I and the lowest in Zone VI. The MVP for insecticides was the highest in Zone II and the lowest in Zone IV. Whereas, for labour it was the highest in Zone IV and the lowest and negative in Zone III. The MVP of expenditure on diesel engine was found negative in Zones V and VI. It was observed that with the optimum use of resources, returns could be increased considerably in all the zones.

Singh et al (1992) investigated the resource use efficiency for un-irrigated and irrigated wheat grown in the watershed areas of Kandi region of Punjab. The important variables viz. crop area, human labour, bullock labour and fertilizer were regressed against the gross returns from wheat. The coefficient of multiple determination indicated that about 57 per cent to 79 per cent of the variation in the value of output from un-irrigated and irrigated wheat respectively was explained by these variables. It was seen that under rainfed conditions, fertilizer application was not only essential to get higher yields but was highly remunerative too. The use of human and bullock labour was rather excessive for both the irrigated and un-irrigated wheat with negative MVPs thus indicating the need for a look at reducing/rationalizing their use.

Sagar (1995) investigated the response of fertilizer use in Indian Agriculture. The study was an attempt to verify the findings that showed the diminishing marginal physical product of fertilizer in the major cereals viz; paddy and wheat. He used the data related to fertilizer use under field conditions as well as that of experimental and semi-experimental responses from various sources. These included state level crop-cutting experiments, cost of cultivation of principal crops and All India Coordinated Agronomic Research Project. He employed linear and non-linear response functions and also brought out derived fertilizer responses and took up three technological inputs namely, H.Y.V, irrigation and fertilizers.

Singh (1996) made an investigation on “Efficiency of Input Use in Indian Agriculture”. He found that the growth rate of aggregate agricultural productivity in India during 1980-81 to 1994-95 had been lower than the growth rate of fertilizer use, power consumption and institutional credit, but more than the growth in irrigation water. The share of modern inputs increased from less than three per cent in pre-green revolution period to more than 33 per cent in 1990s’.
Singh (1997) estimated the field level response for important crops and examined the changes in response overtime as well as the extent of variation in the use of important inputs and their overall impact on productivity. The crop cutting experiments’ data regarding the principal crops of the Punjab State i.e. wheat, paddy and cotton at two points of time viz; 1980-81 and 1992-93 were collected from the State Department of Agriculture. The analysis was done for three zones of the State separately and for the State as a whole.

Thakur et al (1997) studied the resource use efficiency for sheep and goat farming in Himachal Pradesh. Two zones viz; Zone-III and Zone-IV of the State comprising the districts of Shimla, Kangra, Chamba, Kinnaur and Lahul Spiti were selected in view of the higher concentration of sheep and goat. Two stage stratified random sampling technique was followed with villages as the primary and shepherd households as secondary and final units of the sampling. A sample of 268 shepherds with 142 small, 88 medium and 38 large herd-sizes was selected. To examine the input-output relationship for sheep and goat rearing, the Linear and Cobb-Douglas functions were used. The regression analysis showed that herd-size had significant impact on income of all sizes of farms. The returns to scale indicated that the shepherds should increase the income as they were found to operate in irrational zone (Stage I) of production function. The marginal value productivities (MVPs) also suggested that shepherds should increase the herd-size and increase the use of concentrates.

Haque (2006) studied on “Resource Use Efficiency in Indian Agriculture” highlighted farmers’ tendency to maximize physical productivity per unit of land. It might lead to over-exploitation and degradation of farm resources. He emphasized economic as well as environmental aspects of resource use efficiency. It was observed that the factor productivity in agriculture overtime showed a deceleration. The productivity of major crops such as paddy, wheat, sugarcane and cotton faced this situation in the major growing areas. There was found a scope for raising the crop productivity through improved management practices. As evidenced from the cost of cultivation statistics, there were inter-regional and inter-farm variations in factor productivity. Among the factors influencing crop productivity, such factors of production as irrigation for cotton, seeds in paddy, wheat and cotton were found to possess negative elasticity in major crop growing states. The other factors enlisted include erratic weather, small size of holdings and insecure land tenancies.

Kumar et al (2008) worked out the technical efficiency of paddy farmers in Punjab. The cross-section data relating to the various inputs and output for paddy cultivation were taken
from the project “Comprehensive Scheme to Study the Cost of Cultivation of Principal Crops” in operation at Punjab Agricultural University. The normal agricultural years 1985-86 and 2002-2003 were chosen for this investigation.

Dhingra (2010) studied that the improved strains of seeds are essential for increasing agricultural production. Unless the farmer has good seeds of suitable varieties, he cannot get the best out of other inputs, such as irrigation, fertilizers, insecticides and machinery. With HYV seeds, it becomes possible for him to take to intensive agriculture because of the resultant high yield and good economic returns. When one seeds in retrospect, it becomes clear that much of the stagnation that prevailed in India agriculture till the mid – 1960’s could have been explained in terms of the availability of poor and low-yielding variety seeds.

2.3 Status of Farm Mechanization

Chung and Kim (1990) discussed progress of farm mechanization during the last 25 years in rural areas with an emphasis on its directional sift and the problems and their solution in countered act different phases of the progress. Farm mechanization was conceived as successful accomplishment as far as rice production is concerned because the number of power tillers has increased by more than 2.5 times, tractors 9.2 times, transplanter 7.6 times and combined about 21 times from 1982 to 1988.

Zeren and Isik (1991) studied the relation between agricultural inputs, mechanization and employment in Turkey. They observed that human and animal were the major source of power until 1970 when tractor power started to became popular. Between 1975 to 1987, manual and animal power sources declined to a very low level in contrast to farm tractors, which were supplying over 90% of the total farm power. In terms of farm mechanization level, this has increased from 0.04 kW/ha in 1960 to 0.97 kW/h in 1984. They found that tractors and agricultural machinery that affected increase in production have an important role among the production technologies. Tractors and agricultural machinery manufacturing sectors have also an important place in employment.

Khan (1992) studied farm mechanization in the Rajasthan (India) and observed that farm mechanization started in 1940’s when some progressive farmers moved a little forward to test the improved agriculture machines and the results were very encouraging. However it gained momentum only in the post green revolution era (1966-1967). In 1988, about 87000 tractors
were on the farms as compared with only 15 in 1945. In just 16 years (1972-1988), the population of tractors, tillage implements, mechanical seeders, pump sets and power threshers increased by about 7, 6, 10 and 25 times respectively. The major constraints in farm mechanization was financial resources of farmers. Repair and maintenance of tractors and equipment was another constraint in farm mechanization.

Mirdha (1993) studied the prospects of agriculture mechanization in Tonga and indicated that traditionally, most farmers perform farm activities with the use of bush knife, fork, spade, hoe and axe. For transportation of their products, they use cart. Due to lack of appropriate technology in the production system, crops yield are low. Although in the fourth five year development plan (1985-1990) the government gave more emphasis in acquiring more tractors and implements, still the number of tractors was not sufficient to meet the demand. The acquisition of the tractors and necessary implements was very costly and beyond the farmers purchasing capacity. In addition, most of the farmers were not technically trained in the operation, care, maintenance and repair of highly technical, powerful and costly tractors, other machines and equipment.

Verma and Singh (1994) discussed the needs and prospects of mechanizing Indian agriculture. They found that Indian farmers were slowly picking up modern techniques of crop production and management such as improved seeds, fertilizers, pests and weed control methods for increasing production. Although efforts have been made since the last two decades to mechanize agriculture, only marginal success has been achieved.

Sue (1995) studied the recent developments in the agricultural mechanization in Taiwan. It was found that almost all the farm operations, form land preparation to harvesting have reached a level of mechanization by 95% in rice production. This was made possible through the custom hiring services and rice nursery centers, which were widely set up throughout the island and constituted a compete service network for the most of the farmers, replacing lots of the farm labour.

Makanga and Singh (1997) studied the status of agricultural mechanization in Kenya. Low level of mechanization was observed particularly with the small scale farming community, where the use of hand tools was very common.
Tsheko and Mahapatra (2003) studied the status of agriculture mechanization in Botswana and observed that the human power contributes 6240 kW which was about 6.2% of total power available for agriculture. Draft animal power availability was 14200kW and mostly used for ploughing and transport to collect water. Tractor power available for agriculture was 80,000 kW. Minimum power requirement was 217,944kW for total crop land area of 290,592 ha for effective agricultural by assuming 0.75 kW/ha, which leads to a deficiency of 117,504 kW i.e. 54% of the total requirement.

Kebebe et al (2000) studied the diversification of agriculture in Haryana. The study revealed that cereals, commercial crops, vegetables and fruits were found to be relatively more diversified as compared to pulses and oilseeds among the crop groups. Diversification towards high-tech, innovative enterprises within the agricultural sector, such as vegetables, fruits and towards agro-food processing and rural non-farm sector has been gaining momentum in the State.

Das (2000) studied the agricultural cropping pattern in different zones; their average yields in comparison to National average yield potential. Multiplicity of cropping systems has been one of the main features of Indian agriculture and it is attributed to rain fed agriculture and prevailing socio-economic situations of the farming community. He estimated that more than 250 double cropping systems are followed throughout the country and based on the rationale of spread of crops in each district in the country, 30 important cropping systems have been identified.

Reddy and Achoth (2000) studied the determinants of cropping pattern changes in dryland agriculture of Karnataka. The study exposed that most of the dry land, food crops such as rage, jowar and Bengal gram were non-responsive to own price and oilseed crops such as sunflower and groundnut responded largely to their own prices. Most of the crops respond positively to the rainfall except groundnut area.

Subhashini (2001) studied the shift in cropping pattern in Tamil Nadu state and South Arcot district with special reference to oilseed crops. She conducted analysis of the three year average of area under major crops in four categories viz., (1) Paddy, (2) Oilseeds, (3) other food crops and (4) non-food crops before and after removing open general license. The results indicated that in Tamil Nadu except paddy, the other three categories experienced a reduction in the area by 16.69, 10.85 and 2.76 per cent, respectively. In the South Arcot
district, there was a huge fall in the share of groundnut area i.e. by 36.2 per cent. Other non-food crops also experienced a fall in the area by 7.21 per cent.

Hazra (2001) deliberated the changes in cropping pattern at the all India level by considering the area share of crops and crop groups at four time points, capturing, respectively the Triennium ending average of areas at 1966-67, 1976-77, 1986-87 and 1996-97. The study revealed that there was a shift from traditional grown less remunerative crops to more remunerative crops. This crop shift took place due to government policies and thrust on some crops in a given time.

Virender Kumar (2002) examined the changing cropping pattern in Himachal Pradesh reported that total cropped area increased by about 21 thousand hectares from 16.69 per cent to 17.06 per cent of the total geographical area during the period 1972-96. The area under wheat, as percent of total cropped area, increased from 34.27 per cent to 37.66 per cent that of maize went up from 28.11 per cent to 32.58 per cent. The magnitude of decline in percentage share in the area in Ragi and other millets was much higher than that of barley.

Goswani et al (2003) studied to evaluate the changes of cropping pattern in Mizoram. They stated that during the period under study maximum growth rate in area achieved in pulses (13.82 per cent) followed by tapioca (9.46 percent), oil seed (7.06 per cent) and maize (3.25 per cent). Area under sugarcane and cotton was showing a significant negative growth rate of 2.56 per cent.

Joshi et al (2004) studied the determinants of agricultural diversification in South Asia. Independent variables such as irrigation, productivity, markets, literacy, land holdings and rainfall were considered for study. They concluded that the irrigated area significantly contributed for diversification and the regression coefficient of the irrigation variable also showed negative relationship with diversification.

Goswami and Challa (2004) conducted a study to understand the land use pattern in India for the period 1950-51 to 1997-98. The results indicated that forest area had increased from 40.08 million Ha in 1950-51 to 68.65 million Ha in 1997-98. There was significant increase in area under non-agricultural uses from 9.36 million Ha in 1950-51 to 12.3 million Ha in 1997-98. They also revealed that the net area sown increased during the period 1951-1971. However, after 1971 the area is established to have remained same till 1997–98.
Sreeja (2004) conducted a study to understand the changes in land use pattern in Kollam district of Kerala. The results indicated that there was a considerable growth in the current fallow, which reflects the consequence of year to year rainfall variations presentation the inverse relationship between rainfall and current fallow. Barren and uncultivated land, permanent pastures, land under miscellaneous tree crops and groves and cultivable waste recorded a significant negative growth.

Shafi (2006) opined that land use and cropping pattern was integrated. He found out that cropping pattern in any place is largely determined by the amount and distribution of rainfall.

Munish (2007) conducted a study to understand the growth and changes of Indian agriculture since the eighties. The study revealed that agriculture sector was traditionally regarded as having low price responses. Cropping patterns were different in different areas because of economic reasons or technological reasons, but the change was slower.

Subrata (2007) conducted a micro level study on economics of cropping pattern changes in relation to credit in West Bengal. The study concluded that the credit availability from institutional and non-institutional sources had made an important contribution to the change in cropping pattern. But the impact of credit availability on cropping pattern change had been more significant in the case of the smaller size of land holdings. Again, the profitability was also higher in the case of small and marginal farmers.

Batla (2008) studied the regional dimensions of inter-crop diversification in India and observed that inter-crop area shifted in favor of high yielding crops like wheat, paddy, oilseeds, cotton and sugarcane, up to the eighties and towards paddy, sugarcane, fruits vegetables, fibers, plantations, condiments and spices during the nineties and early 2000. The area under wheat and paddy had expended solely at the cost of low yield growth crops like coarse cereals and pulses due to price support and HYV program.

Tingre et al (2008) made an attempt to study the cropping pattern changes and crop diversification in Akola district of Vidarbha. The study exposed that majority of cereal crops showed negative and low growth rates of area during the study period. Soybean had attained an important position in the cropping pattern. The trend of crop diversification and cropping intensity increased significantly.
Ramappa and Naidu (2009) conducted a study to understand the land utilization pattern in Andhra Pradesh. The study revealed that the possibility of extensive agriculture was very limited since the area under agricultural uses had by now reached the maximum level. The area under non agricultural uses had increased from time to time. This certainly reduces the size of cultivable land. Modify in cropping pattern was also necessary to make the most efficient use of land.

Wani et al (2009) conducted a study to understand the determinants of productive and unproductive land utilization in Jammu and Kashmir. The study had chosen cropping intensity as an endogenous variable in productive land utilization and current fallow as variable in unproductive land utilization. The estimates of exponential function for productive land use revealed that the net irrigated area, literacy level and are not available for cultivation were positive and important determinants of the variation in cropping intensity.

Meenakshi and Indumathy (2009) studied the land utilization and cropping pattern in Tamil Nadu. The study revealed that there was a substantial reduction in the cultivated area and hence output was affected to a great extent. The cropping pattern in the state had a high degree of maladjustment for crops. Roughly 53 per cent of the cultivated area was being used for growing unsuitable crops.

2.4 Factors contributing to changes in cropping pattern.

Todkari et al (2010) conducted a study to analyse the agricultural land use pattern at the micro level in Solapur District based on the secondary data. Agriculture production is influenced by physical, climatological, socioeconomic, technological and organizational factors. Thirteen crops have been considered for crop ranking and crop combination. Among these, jawar, wheat, bajara, sugarcane, gram, maize, safflower, cotton, etc. are the major crops. By computing crop ranks and crop combination in Solapur District has identified ten crop combination.

Bhupinder and Santosh (2010) analyzed the diversification of agriculture in Haryana. Primary data was collected from a total of 420 respondents covering three districts, six districts and six villages. They have chosen variables for the study based on the problems expressed by sample farmers. Farmers have reported problems like price, number of regulated markets, transport, finance, literacy, irrigation, etc. The major problems faced by the farmers were price fluctuation and finance related aspects.
Bhat and Shah (2011) studied the Land Use and Cropping Pattern in Jammu and Kashmir. The State depends on subsistence farming without any surplus, but from the last few decades a great change has taken place in the variety of crops. The cropping pattern is influenced by physical, technological and institutional factors like land reformation, consolidation of holdings and credit facilities, price structure, procurement policies and storage facilities.

Barakade et al (2011) conducted a study to analyze the agricultural land use pattern at the micro level in Satara District. Agricultural production is influenced by physical, climatologically, socio-economic, technological and organizational factors. An endeavor is made here to study crop comb inaction regions in Satara District for the year 2008-09.

Hangaragi (2011) studied the spatio-temporal changes in cropping patterns in Bagalakot district of Karnataka. India witnessed considerable change in Land use and cropping pattern. The intensive growth of population pressure and attendant demand of land to accommodate various activities are the prime drivers of change. The cultivation of commercial crops has an impact on the socioeconomic development of formers compared to food crops growing formers.

Gomatee (2012) studied the agricultural land use pattern at the micro level in Bulandshahr district of upper Ganga -Yamuna Doab. Agricultural land use pattern and production are influenced by physical, weather, socio-economic, technological and organizational factors. An effort has been made here to study the changing land use pattern, cropping pattern, pattern of crop diversification, crop combination and ranking of the crops. The major crops of the area are wheat, rice, sugarcane, maize, pulses, millets, vegetables, barley, mustard, potato and fodder, etc.

Naik (2012) studied the soil salinity and its impact on cropping patterns in Shirol Taluk. About 187.8 million hectares (approximately 57%) out of 328.27 million hectares of land areas has been degraded in the country. Among these 10.1 million hectares suffers from soil salinity problem. Soil salinity occurs mainly due to two factors viz. Physical and chemical.

Appala Raju (2012) studied the patterns of crop concentration and diversification in Vizianagaram District of Andhra Pradesh. The term ‘crop specialization’ indicates cultivation of less number of crops and crop diversification implies raising a variety of crops from the soil. In this paper an attempt is made to analyze the crop concentration and diversification.
Shakeel and Kanth (2012) conducted a study to assess the land form and land use analysis of Liddar River Basin, Kashmir. The study revealed that second and third order land forms that are utilized by man and nature for different purposes. The land use/land cover status of older basin 1974-75 and 2001 have revealed that there has been a drastic change in the forest area as well as agricultural sector and other classes. The main reason behind this change is mainly due to large scale deforestation, erosion and biotic interference that has increased manifold with the passage of time.

Bhat (2013) studied the agricultural land-use pattern in Pulwama District of Kashmir Valley. They defined that agricultural land as the land which is used primarily for production of food and fiber. Cropping pattern in any region has undergone an evolutionary process. The choice of cropping system is dependent primarily on physical variables and secondarily on size of operational holding, market and transport facilities, capital, price policy of the government and techno-organizational factors. In any region cropping pattern is yield oriented because the farmers try to maximize their production.

Bagade and Chalwadi (2013) made an attempt to study the spatial analysis of crop combination in Belagavi District. They proposed that, crop combination is a scientific device to study the existing spatial relationship of crops in association with each other in agricultural Geography and land utilised ion. Crops are generally grown in combination and it is rarely that a particular crop occupies a position of total isolation from other crops in a given aerial at a given point of time. They concluded that in recent years, the concept of crop combination has engaged the attention of geographers and agricultural scientists and land use planners.

Uppar et al (2013) conducted a study to understand the land use patterns in Haveri District with a geographical perspective. Land utilization is an important predicament for the planning process because of the finite nature of land resources. Agricultural Scientists, Economists, Geographers and other experts are engaged in the study of agriculture. They proposed that land utilization required proper planning and land being a finite resource.

Joydeep Saha (2013) studied the crop diversification in Indian agriculture with Special Reference to Emerging Crops. He revealed that crop diversification is found to be continuing over the time period and most of the states are associated with this process. He also proposed that although food crop dependency persists strongly, commercial and horticultural crops are emerging significantly.
Korade and Rakesh (2014) conducted a study to understand integrated land use/land cover analysis of Surat District, Gujarat by using digital classification technique. They proposed that, land use and land cover assessment using satellite imagery provides reliable and accurate information, which is cost and time effective. It also offers a holistic view of large areas for better monitoring of land use and land cover occurrence and distribution.

Mishra and Pankaj (2015) studied the agricultural land resource utilization in Trans-Yamuna region in Allahabad District, Uttar Pradesh. They proposed that, Indian agriculture occupies a prominent place not only because it supplies food to the people, raw materials to the industries and various items of export trade, but also because it constitutes an integral part of our culture and tradition and the general fabric of life in the country.

2.4 Effect of farm mechanization on the agriculture system

Kumaresan et al. (2005) stated that it was inferred that, between the technological and input use differentials, which together contributed to the total productivity difference of the order of 33.72 per cent, the former alone accounted for 31.61 per cent. This implied that paddy productivity could be increased by about 31.61 per cent if the farmers could switch over to from traditional method to SRI method with the same level of resource use as in traditional method. However, the contribution of differences in input use between SRI method and traditional method of paddy cultivation to the productivity difference was meager at 2.10 per cent.

Based on the decomposition analysis carried out for assessing the total difference in income from cocoon production between the large-scale and the small scale sericulture farmers carried out by author was found to be 31.08 per cent. Among the different sources contributing to the income difference, the technology or the management practices contributed maximum (25.01 per cent) to the income gap for the large-scale farmers compared to the small-scale farmers. Among the components of technical change, the contribution of neutral technical change in the income reduction was estimated to be 25.72 per cent in contrast to the positive contribution of 0.72 per cent by the non-neutral technological change towards the net income in cocoon production.

Bisaliah (1977) estimated the value of additional resources required to produce the new technology level of output by old technology as Rs.67 per acre. The farm firms in Ferozepur
district (Punjab) would have required additional resources valued at Rs.67 per acre to produce the new technology level of output during the year 1967-68 in the absence of new technology using old technology. For the entire state of Punjab, the total value of resources saved was estimated to be Rs. 10.6 cores and for all India Rs.48.7 crores for the year 1967-68.

Singh (1977) estimated the Cobb-Douglas production functions based on the cross district and time series data for the pre-technology (1960-65) and post technology (1969-72) periods for Punjab and estimated growth in output to be 33 per cent. He opined that every rupee spent on research in Punjab has yielded a return of Rs.28.64.

Kumar et al. (1977) treated the value of inputs saved by adopting the new technology of milk production (Indo-Swiss Cattle Breeding Programme), a product of research and extension as benefit of the project. Benefits and costs over the years were estimated by using 1973-74 prices. They reported that the value of inputs saved increased with increase in productivity over the years and was maximum in 1999. The expenditure on research and extension attained its maximum value in 1976 and continued into perpetuity. The internal rate of return was found to be about 29 per cent, implying that on an average one rupee invested in the research and extension activities of Indo-Swiss cross-breeding project yielded a return of 29 per cent annually from the date of investment.

Alshi (1981) estimated the gross value of inputs saved as a result of development of new varieties of cotton to be Rs.163.5 million for Akola district, and Rs.1202.2 million for entire state of Maharashtra for the year 1979-80. Also, the additional quantity of cotton output with no extra cost was estimated at 36.17 thousand tones for the Akola district and 265.80 thousand tonnes for the Maharashtra state during the year 1979-80 at the existing level of adoption of new cotton seed technology.

Hiremath (1989) estimated the gross value of inputs saved as a result of development of new varieties of tobacco to be Rs.7.31 crores for Belgaum district and Rs.7.97 crores for the entire state of Karnataka during the year 1983-84. During the same year due to the adoption of new technology in tobacco, additional output gained was estimated at 9.159 million kg for Belgaum district and 10.44 million kg for Karnataka state.

Singh (2006) studied on the estimation of a mechanization index and its impact on production and economic factors of India. Author stated that A mechanization index based on the ratio of cost of use of machinery to the total cost of use of human labour, draught animals and machinery has been suggested for estimation. For the assessment of the mechanization
index, and to study its impact on yield, cost of cultivation and deployment of human and animal power, crop-wise secondary data have been adopted from the cost of cultivation of principal crops in India. The analysis revealed that, even though 78.5% farm power was contributed by mechanical and electrical power sources the mechanization index at an all-India level was only 14.5%, and it varied from 8.2% in sorghum and paddy to a highest value of 29.00% in wheat. It also revealed that the states having higher crop yields have adopted higher levels of mechanization to ensure timeliness and to reduce the cost of cultivation on a yield basis as observed in the state of Punjab. The analysis has further revealed that as a consequence of adoption of mechanization reduction in the use of human labour has not been significant, but the use of draught animals has reduced at a negative annual growth rate of 6.22%, during 1971–72 to 1996–97.

The level of mechanization index in the country is very low in other crops viz. paddy, sugarcane, groundnut etc. and therefore, plenty of scope exists to introduce mechanically operated equipment. Inputs for mechanization require long-term investment for creating support services infrastructure for manufacture, marketing, after-sale service network, training, demonstration, and credit support. The Government of India is conscious of these facts and has taken adequate measures to promote mechanization by providing financial incentives to the farmers and to the farm machinery industries to manufacture quality farm machinery.

Tewari et al. (2012) studied the farm mechanization status of West Bengal. Author stated that a suitable cropping pattern of crops like paddy, potato helps to increase the productivity of the crop yield in the State. It was noted that introduction of implements and machinery would definitely increase the present status of crops for the State. Human resources were inadequate in most of the regions in State to complete transplanting and harvesting operations in paddy and sowing and digging in potato crop. This indicated the needs of transplanted and harvester machineries for these operations in paddy and automatic potato planter and potato digger in potato crop. Major cost contributions come from initial machinery and prime moves cost in the mechanization options. Technological advancement of tractor and allied machinery manufacturing, policy incentives to encourage manufacturing of quality machinery and some social changes of farm machinery operation through custom hiring and off field works (to increase annual use) would reduce the operational cost. Banks provide term finance to farmers for development purposes and short term loans for production purposes.
Author also suggest a need to finance farmers for purchasing machinery, implements to expand new activities like custom hiring service, agro-service center and make existing small and marginal units economically viable.

Mehta (2013) defined the agricultural scenario of the India. Author elaborated the reason of the poor condition of the agriculture in India. The main factors were the Poor utilization efficiency of critical inputs like water, seeds, fertilizers, chemicals and energy. Benefits of engineering R&D not reaching the farmers expeditiously and very high post harvest losses in grains and perishables and only 10% of produce is processed in the country as against 40-60% in other South Asian countries while very low value-addition in production catchments Nutritional insecurity of rural population.

Nagaraj et al. (2013) conducted a study to know the knowledge and adoption level of paddy growers of Raichur district about farm mechanization practices. The study was conducted in Sindhanur and Manvi taluks of Raichur district comprising 120 respondents from six villages. The result showed that nearly half of the respondents (45.00%) belonged to medium level of overall knowledge category about farm mechanization practices. Majority of the respondents had complete knowledge i.e., mode of operation, frequency of use and specification of the implements such as mould board plough, harrow, cultivator, power tiller, cage wheel, puddler, sprayer, combine harvester and thresher. Further, less than half of the respondents (42.50%) belonged to medium level of adoption category. As in case of knowledge level, large majority of farmers used the implements viz, Mould board plough, harrow, peddler, cultivator, cage wheel, power tiller, sprayer, combine harvester and thresher. However, only (15.00%) of the paddy growers possessed skill in the use of paddy transplanter due to its recent introduction.

Govt. of India (Twelfth Five Year Plan 2014) stated the guidelines of sub-mission on agricultural mechanization operations. The main objectives of this mission were to increasing the reach of farm mechanization to small and marginal farmers and to the regions where availability of farm power is low; to promoting ‘Custom Hiring Centre’s to offset the adverse economies of scale arising due to small landholding and high cost of individual ownership; to creating hubs for hi-tech & high value farm equipments; to creating awareness among stakeholders through demonstration and capacity building activities and ensuring performance testing and certification at designated testing centers located all over the country.
Mehta et al. (2014) studied about status, challenges and strategies for farm mechanization in India. The production and productivity in Indian agriculture could not enhanced by primitive and traditional practices of farming. The average farm size in India is 1.16 ha and mechanizing small and non-contiguous group of small farms is against ‘economies of scale’ especially for operations like land preparation and harvesting. With continued shrinkage in average farm size, more farms will fall into the adverse category thereby making individual ownership of agricultural machinery progressively more uneconomical. The combine share of agricultural workers and draught animals in total farm power availability in India reduced from 60.8 % in 1971-72 to 10.1 % in 2012-13. The average farm power availability needs to be increased from 1.84 to 2.5 kW/ha by 2025 to assure timeliness and quality in field operations. Therefore, India adopts a policy of selective mechanization under diverse conditions, which makes the agricultural mechanization a challenging task. The widely fragmented and scattered land holdings in many parts of the country need to be consolidated to give access for their owners to the benefits of agricultural mechanization.

The small farms can be mechanized by use of improved manual tools and animal drawn farm equipment on individual ownership basis or high capacity farm machinery on custom hiring basis. Medium and large scale farmers may be provided with Govt. subsidies to encourage them to buy and to apply advanced medium and high capacity machinery such as cotton picker, rice transplanter, sugarcane harvester and combine harvester on their fields. The farm machinery bank may be established in low farm power availability region for machines being manufactured elsewhere in the country. There is a need to innovate custom service or a rental model by institutionalization for high cost farm machinery and can be adopted by private players or Governmental organizations in major production hubs. The quality manufacturing and after sales support for farm machinery are also needed for reliability of farm machinery.

2.5 Growth of Farm Mechanization in Uttar Pradesh

Majumdar (2000) studied the status and few strategies of farm mechanization in Uttar Pradesh, India. To meet the future growing food requirement, production has to be increased to a growth rate of 3.7% per year (Yadav, 1999). Farm mechanization is an answer in this regard to get full efficient utilization of the inputs. Though much emphasize has been giving on farm mechanization since ’70s, satisfactory breakthrough has not been achieved in most of the states of India; virtually the technology could not been percolated from the research stations to the farmers field. It was reviewed that in Uttar Pradesh, mechanization in agriculture is not up to the mark because of the problems which are mostly social, economical
and technical in nature. Efforts have been made in this paper to study the status in regard to mechanization and to suggest various recommendations to overcome these problems.

**Agriculture Census Division, GOI (2006)** this report stated and explained about the status of agriculture in Uttar Pradesh. Report stated that agriculture in Uttar Pradesh had crucially dependent on monsoon. Although around 57 percent of its gross cultivated area was irrigated, irrigation itself was crucially dependent on monsoon as it largely depended on the use of surface water. According to the soil quality and climatic conditions of the relevant areas, Uttar Pradesh has been classified in 3 agro-climatic zones: North-West Alluvial Plane (Zone 1), North-East Alluvial Plane (Zone 2), and South Alluvial Plane (Zone 3), the last zone being further classified in two sub-zones 3A and 3B. Monsoon arrives earliest in the northeastern Zone 2, which also receives the highest rainfall among all three zones. Zone 3 receives monsoon showers last of all three zones and also the least amount. Total irrigated area in the State is 45.67 lakh hectares, of which nearly 30 percent is fed by canal water. This highlights the monsoon dependence of even irrigated lands as catchment areas of nearly all the major rivers in the State are outside the state.

**Shambhu (2007)** stated that the pace of farm mechanization was very slow in Uttar Pradesh state as compared to many advanced states of the country. A study was undertaken to identify the status of farm mechanization in Allahabad District of Uttar Pradesh. A survey was conducted in three districts of the district having different geographical areas. The only manually operated improved equipment were sprayers, dusters and chaff cutters numbering 27, 9 and 470 per thousand hectare, respectively. In the case of bullock drawn equipment, cultivator, bullock carts and cane crushers were 103, 22 and 9 units per thousand hectare, respectively. The average number of tractors per thousand hectare area was 17 which were higher than other districts of the state. Only cultivators and trailers were used with the tractor. The number of tractor operated threshers were eight whereas other power operated threshers were 203 per thousand hectare area. The bottleneck in mechanization was due to lack of extension programmes, availability of equipment, farm roads and consolidation of land holdings.

**Jha et al. (2008)** stated that Uttar Pradesh agriculture has the potential to grow rapidly so as to meet the existing shortages and assume primacy in the national agricultural economy. The State has immense agricultural resources, to facilitate a Second Green Revolution in the Country. Uttar Pradesh must aim at an annual agricultural rate of 5-6%. However, despite the
strength of the agriculture sector, it is a paradox that this sector is growing at a snail’s pace. The rate of growth has been below its potential. There has been a conspicuous failure to exploit those resources to the desired level. This study has endeavoured to identify the factors behind the dismal performance of the sector. A micro level analysis of the data shows that there are wide productivity differences among different regions in the State. From among the crop sector, yields of maize, gram and sunflower were higher than all India average. But area under all these crops is very small. The country at present suffers from a severe shortage of pulses and oils. Because of the development of poultry, demand for maize is also rising fast. The study has found that due to an appreciable increase in the irrigated area, there is likelihood of an increase of over 2 million hectares in the gross cropped area. If so, a major chunk of this area should be allocated to these crops to meet the national requirements and help bring sustained food security of the country.

**Shambhu and Chaudhary (2012)** stated that farm mechanization was a very important input in agricultural production. The number of tractors has increased rapidly and population of draft animals has been decreasing in Uttar Pradesh in recent years. A study was undertaken to find the tractor utilization pattern and their economics in Allabad District of Uttar Pradesh. The average annual use of farm tractors was 1,772.62 hours, in which about 70.47 % were used in custom hiring and only 29.53 % used for personal work. Maximum use of the farm tractor was 54 % in transportation. The average cost of operation of a tractor was Rs. 145.20 per hour for an 18.65 kW tractor and Rs. 168.15 per hour for a 26.11 kW tractor. The cost of operation decreased with the increase in annual use of the tractor. Also, the total operational cost per hour increased with the increase in size of the tractor. The annual use of tractors in tillage, threshing, agricultural purpose transportation, custom use and miscellaneous use was 14.69, 1.18, 5.59, 70.47 and 8.06 % of total annual use, respectively. The average Break-Even Point (BEP) of a tractor was about 596.42 h/year for an 18.65 kW tractor and 685.20 h/year for a 26.11 kW tractor. Average annual use in each case was higher than their break even points, indicating that their purchase and use in the study area was profitable.

**GOI (2012)** stated the agriculture condition of the Uttar Pradesh state. Uttar Pradesh has a total geographical area of 93.60 lakh hectares on which it houses a population of 82.9 million, thereby generating a population density of 880 persons per sq. km (Census 2001). Gross sown area in the State is 79.46 lakh hectares, while net sown area is 56.03 lakh hectares.
There are around 1.04 crore landholdings in the State of which around 83 percent are marginal holdings of size less than 1 hectare. With around 90 percent of the total population living in rural areas, agriculture as the primary feeder of rural economy continues to operate not only on margins of land but also on the margins of human enterprise, its productivity being among the lowest in the country. Without increasing returns to these margins, not much can be done realistically to develop the agricultural sector. Thus, agriculture continues to define both the potentialities and constraints to development in Uttar Pradesh.

**Ingole (2014)** examined the impact of mechanization on productivity. Mechanization in Indian agriculture started with the establishment of the Central Tractor Organization (CTO) mainly for land reclamation and development, mechanical cultivation. The production of irrigation pumps and diesel engines started during 1930s. The manufacture of tractors and power tillers started in 1960. Since then by the virtue of its inherent edge over the conventional means of farming, agricultural mechanization has been gaining popularity. The present study was conducted in Akola district of Vidarba region for the period 2012-2013. From Akola district 5 tahsil were selected randomly i.e. Patur, Balapur, Akola, Akot and Murtizapur. For this study 6 villages were selected from each tahsil of Akola district, i.e total 30 villages selected. The mechanization development level changed in all selected villages over the study period i.e. on an average the composite index of mechanization in 1990 was 0.6757 and in 2013 it was 0.4430. The total contribution explained by mechanization was 10.70 percent in explaining crops productivity. It indicated that the indicators of mechanization contributed 10.70 per cent the productivity of crops.

**2.6 Constraints of Farm Mechanization**

**Singh (2000)** studied the scope, progress and constraints of farm mechanization in India. They reported that there has been an increase in the use of farm machinery in Indian. Agriculture as it contributed to the increase in output due to timeliness of operations and increasing precision in input application. Most of the mechanical inputs have displaced human and bullock labor, which is socially unjustified. Some states, like Punjab, Haryana excelled in farm mechanization, but have experienced it as overinvestment.

**Pandey (2000)** studied the present status and future requirement of farm equipment for crop production and reported that the tractor mounted implements such as moldboard plows, disc plows, cultivators and other crop-specific equipment are widely being used for seed bed
preparation. Seed drills and planters, both animals drawn and tractor mounted, have become popular. Mechanical transplants for rice and vegetable crops are catching up with farmers. Long handle tools and power weeders for weeding and intercultural and manual and power operated sprayers and dusters for application of chemicals have been commercialized. A further requirement for farm equipment and technologies include Rota-tiller for seedbed preparation, till planter, strip till drill, pneumatic precision planter, sugarcane seat cutter planter, vegetable transplants and check-row planter, for sowing and planting. Power weeders and equipment for chemical-mechanical weed management, electro-static spraying and tall tree spraying are required. Harvesting equipment for sugarcane and cotton are required to be developed.

Ganesh (2000) studied the assessment of the alternative farming system in gazani lands of Karnataka. The analysis made an evaluation of the substitute farming systems vz.. Paddy cultivation, paddy cum prawn farming and mixed farming in Gazani lands of coastal Karnataka.

Kumar and Dandapani (2000) studied frequency, intensity and the determinants of pesticide use in rain-fed cotton, by using farm level cross sectional data from Nanded district of Maharashtra. Average pesticide use was 3.2 kg active ingredient per hectare of cotton area. Farmers also used a number of cultural and physical methods directly or indirectly to limit the crop loss due to pest and diseases. The attitude of farmers towards insect pest risk varied and accordingly the use of pesticides. Risk averse farmers used pesticides excessively and indiscriminately. Findings suggested that improving existing stock of knowledge of pests and management practices could help reduce pesticide use.

Yogeshwari (2002) studied economics and environmental implications of pesticide use in paddy in Shimoga district. The study revealed that the average frequency of pesticide applications made by the sample farmers was 18 sprays with range of 12 to 28 sprays during the paddy crop for period of 140 to 145 days as against the 11sprays recommended. It was found that expenditure on pesticide (Rs. 8389) formed the major portion (31%) of total cost of cultivation of paddy crop. The total cost of cultivation of paddy was Rs. 27,258 per ha. Majority of the farmers used pesticides in the form of organ phosphorus and organ chlorine and 23 per cent farmers used organ phosphorus chemical (monocrtophos) under the brand name Novocron.
Crissman et al (2002) studied potato production and pesticide use in Ecuador and evaluated research and rural development intervention for greater eco-system health. The study reported that the sample farmers employed three of the four main groups of insecticides while using 28 different commercial products. The sample farmers did not use organ chlorine insecticides though found in Ecuador.

German et al (2005) conducted a study to develop a methodology for tracking the fate of technological interventions in agriculture. This article presents a more encompassing methodology for tracking the fate of technological interventions, illustrating the possible applications of findings for enhancing the positive impact of agricultural research and extension in the region.

Singh et al (2005) conducted research on assess the effect of crop establishment methods, weed management and split nitrogen application on weeds and yield of rice. The study revealed that, rice crop suffers more from weed competition unlike other cereal crops. The degree of competition and extent of yield losses varies greatly with rice cultures. Weed competes with crop plants for moisture, nutrients, light, space and other growth factors. In the absence of an effective control measure it leads to removal of considerable quantity of applied nutrients resulting in a significant yield loss. To realize the maximum benefit of applied expensive inputs like nitrogen and higher yield, an effective control of weeds is of utmost important.

Cheryl (2005) analyzed the technology adoption using micro studies and assessed the limitations, challenges, and opportunities for improvement. He proposed that the policy makers and interest groups have many questions about the use of improved technologies in developing country agriculture. Drawing on an extensive review of the literature on the adoption of agricultural technologies, this article suggests alternative approaches for designing technology adoption studies to make them useful for policy makers.

Srivastava et al (2005) conducted a study on weed dynamic and their management in sugarcane under different preceding crops and tillage systems. They reported that sugar cane crop faced intense competition with sedges (abundance index >4) at tillering stage (60 days after planting) irrespective of preceding crops, viz wheat or Indian mustard and tillage systems, viz conventional or minimum.
Jayanthi and Kombairaju (2005) studied the pest management practices in four important vegetable crops, viz. chilies, cauliflower, brinjal and bhendi using farm level cross sectional data. The study reported that average pesticide usage has been estimated at 5.13, 2.77, 4.64 and 3.71 kg active ingredient per hectare on chilies, cauliflower and brinjal and bhendi crops, respectively. On an average, cauliflower and brinjal were each given 15 applications, chilies was given 13 and bhendi was given 12 applications. The study suggested for reducing pesticide-use and went on to conclude that farmers needs to be educated about different non-chemical control methods and should be encouraged to adopt integrated pest management practices.

Suresh and Reddy (2006) conducted a study to assess the resource use efficiency of paddy cultivation in the Peechi command area of Thrissur district of Kerala. Their results showed that average technical efficiency of the paddy farmer in the command area was found to be 66.8 per cent. They also pointed out that education of the farmer and supplementary irrigation provided during the water-stress days have been identified as the major factors, which could enhance the technical efficiency. The study has called for an equitable distribution of canal water and enhanced extension services for resource management in the area.

Das and Nag (2006) conducted a review study on traditional agricultural tools. They proposed that, the agricultural tools are as old as the stone-age and were necessary to facilitate working and to increase the productivity of human workers. New tools were developed using copper, bronze stones, other non-metals like wood, leather, bamboo and fibers were used in tools, but most of them became extinct which the introduction of iron. Starting with the original iron Bakhar blade for tillage in central Indian after the discovery of iron smelting in a mud hearth in Bastar of Chattisgarh state, agricultural tools was designed and produced in scores by village blacksmiths.

Shakirullah et al (2006) studied the nature and extent of adoption of pesticides among small, medium and large farmers in Union Council Palosi, District Peshawar. The results revealed that pesticides were used by 78.75 per cent of the farmers, while 2.25 per cent did not use them. Majority of the farmers (41.25%) started using pesticides 6-15 years ago for different pests. The per annum average cost of pesticide purchase was significantly higher at 1 per cent level for large farmers than medium and small farmers. This shows that the larger farms applied more pest acids.
Erappa (2006) defined contract farming as an agreement between farmers and processing or marketing firms for the production and supply of agricultural products under a onward agreement, generally at predetermined prices. The agreements also allow the procurer to provide a degree of production support through inputs and technical guidance for the crop cultivation. From the farmer’s side, there is a commitment to produce the specified agricultural products within the quality and quantity standards prescribed by the purchaser, and the firm supports, in turn, the farmer’s production, and also purchases the produce.

Prabuddha (2007) studied the pattern of pest infestation on vegetables and the extent of the use of pesticides by vegetable growers in 18 villages in Katwa-1 block, Bardhaman district, West Bengal, India. The study found that the intensity of insect pest infestation on aubergine, pointed gourd (Trichosanthes dioica), cabbage and cauliflower was greatest during the Rabi season, followed by the kharif and prekharif seasons over the last five years. Most of the farmers applied pesticides on aubergine and cabbage, but the application rates, number of chemical groups of pesticides and application frequency adopted by the farmers were more than the recommended. This practice was most pronounced for aubergine, followed by cauliflower, cabbage and pointed gourd.

Ngowi et al (2007) studied pesticide use by smallholder farmers in Northern Tanzania who grew vegetables that include tomatoes, cabbages and onions. They observed that the types of pesticides used by the farmers in the study areas were insecticides (59%), fungicides (29%) and herbicides (10%) with the remaining two per cent being rodenticides. More than 50 per cent of the respondents applied pesticides up to five times or more per cropping season depending upon the crop. Insecticides and fungicides were routinely applied by 77 and 7 per cent, respectively. Majority of the farmers reported that the trend of pesticide use was increasing. Sixty eight per cent of farmers reported having fell sick after routine application of pesticides.

Shailaja and Thirumeni (2007) evaluated 19 finger millet genotypes for seedling characters in seed germinator maintained at 90% (relative humidity) and 25 2” C (temperature). Moderate (EC: 6 dS1m) and high (EC: 12 design) salt-stress was compulsory through moistening of filter paper besides distilled water as a control. Four replicates of hundred seed genotype for each of the treatments imposed were maintained.
Mendola (2007) studied the agricultural technology adoption and poverty reduction in rural Bangladesh. This study was aimed at shedding some light on the possible impact of agricultural technology adoption on poverty mitigation strategies. As technology adoption is not randomly assigned but there is ‘self-selection into treatment’, the paper tackles a practical issue in assessing the causal effect of technology on farm-household wellbeing through the non-parametric score matching analyses. It pursues a targeted evaluation of whether adopting a modern seed technology causes resource-poor farmers to perk up their income and decrease the propensity to fall below the poverty line.

Udayakumar (2008) studied the economic consequence of pesticides used in paddy Kopal district, Karnataka. The excess use of pesticides in agriculture has not only increased production costs but also led to ill effects of pesticide usage. The total cost of cultivation of paddy was found to be Rs 65591.53/ha of which the cost of pesticide accounted for 5.50 per cent. On an average the expenditure on pesticides in paddy cultivation was Rs. 3607.57/ha. The yield obtained by the sample farmers was 66.90 quintals. The farmers realized net returns of Rs. 17145.14/ha of paddy cultivation.

Karthikeyan et al (2009) undertook a study to identify various traditional tools used for agricultural operation by the farmers of Tamil Nadu. They proposed that traditional agricultural tools were economical in terms of labour, money and time saving. These tools were made up of locally accessible materials like stones, wood, etc. traditional tools are operated easily without any special skills. The study was conducted in Coimbatore, Erode, Salem, Krishnagiri, Villupuram, Dindigal, Madurai, Kovilpatty, Aruppukottan and Virudhunagar districts of Tamil Nadu. Information was documented by using Participatory Rural Appraisal techniques like observation and discussion.

Mandhata and Singh (2010) conducted a field experiment during the rainy (kharif) season of 2006 and 2007 to study the efficacy of herbicides under different methods of direct-seeded rice (Oryza sativa L.). Organization of rice by drum seeding significantly reduced the weed density and their dry weight and increased the yield attributing characters finally led to 0.28 and 0.64 tonnes/ha higher rice yield over the wet (4.27 tonnes/ha) and dry seeding (3.91 tonnes/ha) of rice. Weed control efficiency (84.23%) was maximum under this action compared with the other sequential application of herbicides, IE butachlor (71.90%) and pendimethalin (73.85%), followed by 2, 4–D as well as theirs alone applications.
Gangwar and Singh (2010) undertook a field study during 2003–07 at Modipuram to assess the effect of rice (*Oryza sativa* L.) crop establishment methods (direct seeding, drum seeding, mechanical transplanting puddle, mechanical transplanting on puddle and manual transplanting) on ‘PHB 71’ hybrid rice and their carry over effect on wheat (*Triticum aestivum* L. Emend. Fiori & Paul), mustard (*Brassica juncea* L. Czernj. Cos), and Chickpea (*Cicer arietinum* L.) yield and soil properties. Maximum mean yield of rice (8.5 tonnes/ha) was obtained with drum seeding-wet bed. The direct seeding dry bed adopted in rice crop resulted in higher yield of succeeding crops of wheat (5.71 tonnes/ha), chickpea (2.20 tonnes/ha) and mustard (1.86 tonnes/ha).

Simtowe et al (2010) studied the determinants of agricultural technology adoption in improved groundnut varieties in Malawi. They proposed that since not all farmers are exposed to the new technologies it makes it difficult to obtain consistent estimates of population, adoption rates and their determinants using direct sample estimates and traditional adoption models such as profit or Tobit. The findings are indicative of the relatively large unmet command for improved groundnut varieties, suggesting that there is scope for increasing the adoption rate of better groundnut varieties in Malawi once the farmers are made aware of the technologies and if other constraints such as lack of access to credit are addressed.

Anoop et al (2010) conducted a field experiment during 2009 at Ludhiana to test the performance of the direct-seeded drill against manual transplanted. Four treatments were evaluated, voice T1, direct-seeded drill with an adjustment of 30 kg/ha seed rate, T2, direct-seeded drill with a change of 15 kg/ha seed rate, T3, drumseeded puddled transplanted rice with a seed rate of 50 kg/ha, T4, transplanting with a Japanese manual transplanter. Grain yield found to be highest in T4 treatment (7.85 tonnes/ha), followed by T1 (7.8 tonnes/ha), T2 (7.2 tonnes/ha) and T3 treatments (6.1 tonnes/ha), respectively. However, it was found statistically same in T1, T2 and T4 treatments. Grain yield in drum-seeded puddled transplanted rice decreased due to poor crop organization which favored more crop-weed competition at the early stage caused a reduction in panicles/m2 and 1 000-grain weight. Yield attributes were also found statistically same in T1, T2 and T4 method. In direct seeded crop, T1 showed more superiority than T2 treatment revealed that 30 kg/ha seed rate in direct-seeded drill is optimum which favored better plant growth, especially at the early stage due to having a smothering effect on weeds.
Varsha and Singh (2011) conducted a study to assess the agricultural mechanization in Chakai development block in Chandaual district. Agricultural mechanization has made a significant contribution to agricultural production, contributing to overall rural development. The contributing of agricultural mechanization has been well recognized in enhancing the production together with increased irrigation, frequent use of high yielding varieties, biological and chemical fertilizers, pesticides, etc. The present study is confined to the analysis of agricultural mechanization and its variation in different nyaya panchayats.

Shanthy (2011) conducted a study to formulate strategies for effective dissemination of appropriate technologies to sugarcane growers in India. They proposed that, the chances of successful technology dissemination are enhanced by understanding the technology transfer process, the players involved in the process of technology transfer, and by developing strategies that can enhance the prospects of successful transfer. The paper also discusses the thought in detail- if a single extension model/strategy would suffice by itself or an integrated approach tailor made to the situation need to be evolved.

Ghosal et al (2011) conducted an experiment at College of Agricultural Engineering and Technology (CAET), Orissa University of Agriculture and Technology, Bhubaneswar. The bullocks were loaded with 9.8% of their body weight and their speed was measured. The draft and power delivered by the pair of bullocks were also calculated. The paddy thresher was run with a pair of bullocks in rotary mode of operation and three persons were employed for threshing.

Vishwakarma (2011) conducted a study to assess diffusion of high yielding variety of seeds in Chhindwara District, Madhya Pradesh. Knowledge and use of HYVs of tribal and non-tribal communities were evaluated along with inter and intercommunity variation. They proposed that lower socio-economic status of farmers, particularly tribal vulnerable peasantry system and their limited perceptual behavior and less connectivity are other characteristics which persist in the trickle down affects the diffusion according to growth pole theory.

Tapas Pal (2011) in his study proposed that agriculture is the base pavement, Industry is the roof and technology is the pillar architecture of any social development. From Vedic society, Indian agriculture was firmly adopting with traditional techno knowledge. Farmers were mainly eco- lover and to increase their agro-production in relevant of demand-supply ratio they were dependent on natural manure based organic elements. But in 2001 we have crossed
100 crores population's food demand. So, from upper politicians, scientists to lower peasants were thinking that how this food-crisis disaster can be checked? All of them decided that we have to use chemical fertilizers, pesticides, insecticides instead of natural manure. Farmers are doing this in their agro-field and trying to increase the production rate. And the resulting outcome, the production has increased but these contemporary modern techniques are not fruitful and produced for local environment for long term effect and we are staying a risk associate vulnerable periphery

Ajuruchukwu and Future (2011) conducted a study on performance of smallholder agriculture under limited mechanization and the fast track land reform program in Zimbabwe under the unpopular fast track land reform program (FTLRP). They encouraged acquisition and use of tractors by arable crop farmers in communal and resettlement state land. The Stochastic Frontier Model revealed the significant impact of the program on participating farmers, highlighting the significance of land and other productive factors. While overall production and productivity remain low, triggering a hyperinflationary situation due to supply constraints, practical implications for agribusinesses are foreseen.

Tewari et al (2012) conducted a study on farm mechanization status of West Bengal in India. The second Indian Green Revolution to full fill our future food requirements to benefit the small, medium and large size farms needs farm mechanization. They proposed that farm mechanization enhances the production and productivity of different crops due to timeliness of operations, better quality of operations and precision in the application of the inputs. The popular and effective machinery for paddy and potato cultivation in the State has been in use among the farmers.

Adhikari (2012) conducted a study to assess economics of finger millet production and marketing in the Peoria urban area of Pokhara valley of Nepal in 2006 AD. They analysed that the cost of production (NRs. 23847.60/ha) and gross revenue (NRs. 24638.23/ha) of finger millet was significantly higher at Kalabang. The price of finger millet was NRs. 16.91/kg at Kalabang and NRs. 17.35/kg at Begnas. Profit of finger millet cultivation was higher (NRs. 790.58/ha) at Kalabang than in Begnas (NRs 602.45/ha) while the higher benefit cost ratio (1.05) was in Begnas.

Raheleh Fadavi et al (2012) studied the estimation of a Mechanization Index and its impact on energy and economic factors in apple orchard in Iran. The Energy Ratio, Energy
Productivity, Economic Productivity and Mechanization Index were estimated for apple production. Mechanization was considered at three levels including level 1 for spraying only, level 2 for spraying and plotting, and level 3 for spraying and fertilizing operations. The Energy Ratio was found to be less than one for all mechanization levels having the highest value in level 2 (0.58). The highest economic productivity was calculated as 1.9 for level 2. Results showed that increasing the Mechanization Index, will not necessarily increase the energy ratio and economic productivity.

Patil (2012) conducted a micro level analysis of Banage Resettlement wrt irrigation and agricultural development. They proposed that socio economic development of farmer's family depends upon agricultural development. Irrigation has profound impact on the development of agriculture than land size. They concluded that there has been a great change in agricultural development, though families have been resettled with small land holding capacity.

Someshwar (2012) studied the sustainable agricultural development and organic farming in India. They proposed that Agricultural sector, world over, has experienced a phenomenal growth since the mid-twentieth century. The growth, driven by Green Revolution technology, has made a significant dent on aggregate supply of food grains, ensuring food security to the growing population. The next stage of growth however, faces a serious challenge in terms of sustainability.

Shwetha and Narayana (2012) conducted a study under irrigated conditions during kharif season of 2006-07 at Kuvempu University campus to evaluate the performance of organic (Vermicompost and FYM) manures and inorganic fertilizers on paddy crop and their effect on soil fertility. Despite higher soil reserve of available nitrogen (298kg ha-1), available phosphorus (30kg ha-1) and available potassium (336kg ha-1) were found both in the application of vermicompost 15t ha-1than application of conventional RDF alone and no fertilizer application. The result indicated that application of vermicompost @ 15t ha-1 and @ 10t ha-1 + RDF increases the grain yield besides sustaining the fertility status of the soil as compared with 100% of RDF alone.

Mali et al (2013) studied the regional imbalance in the levels of agricultural development of Maharashtra. They simply expressed the development of agriculture in the form of increased
productivity and production. They also proposed that agriculture development is depended on use of new agricultural technology, use of fertilizer and irrigation facilities.

**Suresh and Hurakadli (2013)** conducted a study to assess the impact of irrigation on agricultural development in Malaprabha command area, Karnataka State. They proposed that irrigation is the adjunct of civilization and is one of the most essential inputs next only to land for the agricultural development. Agriculture plays an essential role in the process of economic development of developing countries like India. Agricultural development is an integral part of overall economic development. Only rainfall is the natural source of water for irrigation, but rainfall is the most unreliable and is marked by wide variations in different parts of the nation and also variation from year to year in its quantity, incidence and duration.

**Abhay et al (2013)** studied the regional disparities in the levels of agricultural productivity. They proposed that agricultural development has a multi-dimensional phenomenon, which denotes the quality of an agricultural system in terms of productivity, diversification and commercialization. It is also a manifestation of the combined effect of many factors viz. environmental, technological and institutional. The level of agricultural development may be considered as the degree to which agrarian structure gets strengthened leading thereby to increase production. This also includes increase in the income level of farmers thereby promoting socio-economic transformations.

**Chisango and Dzama (2013)** conducted a study to assess agricultural mechanization index and evaluate agricultural productivity of some fast track resettlement farms in Bindura district of Mashonaland central province, Zimbabwe. The levels of Agricultural mechanization at some farms in two wards of Bindura North district of Zimbabwe were measured and the productivity of each of the surveyed farms was analyzed. The study concluded that, level of mechanization in the two wards is pathetic and lower than the expected national mechanization level. Mechanization of the irrigation systems was totally neglected signifying lack of a comprehensive national irrigation policy to buffer the effects of recurrent droughts which are a result of climate change.

**Anderson et al (2013)** conducted a study to analyze mechanization Index of wheel tractors in rural farm holdings. The study was aimed to analyze the mechanization of agricultural properties in the municipality of Dracena/SP. The study reported that the mechanization index and the farmed area by tractor were, respectively, 2.53 kW/ha and 103.9 ha/tractor. The
analysis further revealed that the field operational cost was minimized with the maximization of the effective operational capacity for any area group.

Nagaraj et al (2013) conducted a study to assess the knowledge and adoption level of paddy growers of Raichur district about farm mechanization practices. The study reported that majority of the respondents had complete knowledge, i.e., mode of operation, frequency of use and specification of the implements such as moldboard plow, harrow, cultivator, power tiller, cage wheel, paddler, sprayer, combine harvester and thresher. Further, less than half of the respondents (42.50%) belonged to medium level of adoption category. As in case of knowledge level, the large majority of farmers used the implements views, Mould board Plough, Harrow, paddler, cultivator, cage wheel, power tiller, sprayer, combine harvester and thresher. However, only (15.00%) of the paddy growers possessed skill in the use of paddy transplanted due to its recent introduction. Environmental Study of Bundelkhand Region. Department of Agriculture and Cooperation (DAC) GOI (2015)
CHAPTER- 3
MATERIALS AND METHODS

In the proposed research work the survey area for study is Bundelkhand region of Uttar Pradesh. In the first phase out of all the districts in five districts of Bundelkhand region stratified multi-stage random sampling design will be adopted for collection of data to study the status of agricultural mechanization and its need. Selection of districts will be made on the basis of mechanization index level viz high, average and low. Mechanization index will be prepared by assigning weight age to different farm machines and tools as suggested in literature. From each mechanization index group certain number of districts will be randomly chosen for the survey. In the second phase from each selected block three to five villages will be randomly selected for survey in consultation with block development officials and village pradhans. A good number of farmers will be selected from each village for conducting detailed survey. Detailed village wise and farmer wise information on crops, area shown, irrigation facility, yield, use of tractors and bullocks, implements and machinery, socio – economic factors etc. will be obtained. Data will be collected on specially designed Performa with respect to village and farmer information. The survey data will be statistically analyzed to study and evaluate the following- Mechanization level in different districts of Bundelkhand region of Uttar Pradesh. Mechanization gap in the region. Status of bullock drowns improved implements use in the region. Implements and machinery suitable for the region. Impact of mechanization on production and productivity. Impact of mechanization on the socio-economic condition. A computer model will be developed to select optimum size of farm machinery and the cultural practices.

3.1 Description of Study Area

Bundelkhand is a region and also a mountain range in central India. The hilly region is now divided between the states of Uttar Pradesh and Madhya Pradesh, with the larger portion lying in M.P. Bundelkhand region, comprising seven (7) districts of Uttar Pradesh (U.P.) viz. Jhansi, Jalaun, Lalitpur, Mahoba, Hamirpur, Banda and Chitrakoot and six (6) districts of Madhaya Pradesh (M.P.) viz. Datia, Tikamgarh, Chhatarpur, Panna, Damoh and Sagar. The Khangar ruled areas of present-day Bundelkhand after the fall of the Chandelas in 1182 A.D. and until the mid-14th century. Their seat of power was at Garh Kundar, a fort built by Khub Singh Khangar. During the Khangar rule, Bundelkhand was known as Jujhauti, implying the
land of warriors. The name of the region derives from the Bundela Rajputs, who succeeded the Chandel Rajputs as rulers of the region in the 16th century.

Among the well-known places of Bundelkhand is Khajuraho, which has numerous 10th-century sculptures devoted to fine living and eroticism. The mines of Panna have been the source of magnificent diamonds; a very large one dug from the last active mine was kept for a time in the fort of Kalinjar

3.1.1 Geography of Bundelkhand

Bundelkhand lies between the Indo-Gangetic Plain to the north and the Vindhya Range to the south. It is a gently sloping upland, distinguished by barren hilly terrain with sparse vegetation, although it was historically forested. The plains of Bundelkhand are intersected by three mountain ranges, the Vindhya, Fauna and Bander chains, the highest elevation not exceeding 600 meters above sea-level. Beyond these ranges the country is further diversified by isolated hills rising abruptly from a common level, and presenting from their steep and nearly inaccessible scarps eligible sites for forts and strongholds of local kings. The general slope of the country is towards the northeast, as indicated by the course of the rivers which traverse or bound the territory, and finally discharge themselves into the Yamuna River. The western frontier of Bundelkhand. Parallel to this river, but further east, is the course of the Betwa. Still farther to the east flows the Ken, followed in succession by the Bagahin and Tons. The Yamuna and the Ken are the only two navigable rivers. Notwithstanding the large number of streams, the depression of their channels and height of their banks render them for the most part unsuitable for the purposes of irrigation, which is conducted by means of ponds and tanks. These artificial lakes are usually formed by throwing embankments across the lower extremities of valleys, and thus arresting and impounding the waters flowing through them.

The geography of Bundelkhand region cannot be discussed in detail without discussing its borders. However, the border of the region remains debatable. The borders of any region are decided on the basis of language, culture, politics, population and development. It is also decided on the basis of locations, climatic conditions, and natural hindrances to communication like rivers, mountains, and lakes. Further, it is also demarcated by less tangible traits like caste, religion, language and culture. The boundary of any region is also demarcated artificially on the basis of demography, development and political convenience. In this way, the Bundelkhand region is confined to 13 districts of both the states—MP and
UP in India. Bundelkhand region is bounded on all the four sides by rivers—Yamuna, Narmada, Chambal, Betwa, Ken, Pahuj and Tons. On the basis of geopolitical variation, Bundelkhand can be divided into four different zones. First, the British districts of Jhansi, Jalaun, Hamirpur and Banda lie in cis-Jamuna Doab and the Plateau tract zone. Second, Bundela kingdoms of Chanderi, Datia and Orchha lie in the plateau and ravines between the Chambal and Betwa rivers. Third, the Bundela kingdoms of Bijawar, Panna, Ajaigarh and Charkhari, and the Panwar kingdom of Chhatarpur lie in the plateau and forest from the river Betwa in the west, as far as the Bhanrar ranges of the Vindhyanas in the east, and to the river Narmada in the south. Fourth, the British districts of Sagar, Damoh and Jabalpur lie in the cis-Narmada southern zone (Jain, 2002, pp. 41-42). As a whole, the region is bounded by the Vindhyanchal plateau in the south, Yamuna river in the north, Ken river in east, and Betwa and
Pahuj rivers in the west. It may be said that Bundelkhand is sandwiched between the northern plains and the rocky soil of the Vindhya ranges.

3.1.2 Climatic Conditions

The Bundelkhand region experienced drought in every 16 years during the 18th and 19th centuries, but during 1968-92, the rate of drought increased by three times. The soil and semi-arid climatic conditions of the region make cultivation an extremely difficult occupation, with uncertain returns for the farmers. The most recent and continued period of poor rainfall recorded in Bundelkhand was in 2004-07. The crisis of Bundelkhand cannot be explained just by a simple failure of rainfall, the distress caused by drought or agro-climatic condition of the region (Perspectives, 2010).

3.1.3 Demography

According to the 2011 Census, Bundelkhand has a population of about 18.3 million, which is more than many countries in Europe, Latin America, Africa and the Asia Pacific. Out of the total population of the region, 77.54 percent population, i.e. 14.2 million people live in the rural pockets. The sex ratio is unfavorable to women as it is 885 per 1000 men in the region and 884 per 1000 men in rural areas of the region. The scheduled caste population is more when compared to the states and national average. One quarter of the population of the region belongs to the Dalit community whereas the presence of tribal communities is low.

3.1.4 Agricultural Demography

The geographical location of Bundelkhand region is such that it acts as a gateway between north and south India. Administratively, it covers 7 districts of Uttar Pradesh viz., Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda and Chitrakut and 6 districts of Madhya Pradesh viz., Datia, Tikamgarh, Chhatarpur, Damoh, Sagar and Panna as well as two tehsils of MP viz., Lahar (Bhind) and Bhandar (Gwalior) spread over an area of 71602.50 km². It is characterized as hot semi-arid eco region along with growing period of 90-150 days. The soils of this region are grouped into two heads viz., (i) red soil and (ii) black soil. It is highly permeable with low moisture retaliation capacity and poor to medium in fertility. Forests cover (including degraded forest land and open tree cover) in the Bundelkhand region is about 15329.89 km² or 21.41% whereas present national status is 19 per cent. Two districts of the region Damoh and Panna have more than the targeted national average under forest cover. The south and southeastern part of the region is characterized by high forest, relatively high rainfall (>1000mm) and moderate human and livestock population pressure.
During past 20 years the forest cover has increased only by 2.69%. But the density of trees has decreased and overall decline is visible. Increasing pressure of animals has further accelerated the process of land degradation and resulted in poor grass cover. The agrarian economy of the region is fully dependent on agriculture and related activities as it is clearly revealed by the utilization of land resource in the region. The population pressure in terms of economic density, caloric density and physiological density in the region were 2.96, 3.02 and 3.28 person/ha in 2001. The average annual growth rate of human and livestock population was recorded as 2.2 and -0.26% respectively. The cereals occupy highest area (54.65%) of the total cropped area of the region. The area under net cropped, double cropped and total cropped has increased by 6.75, 3.75 and 13.64% respectively in the region but the maximum gain noticed in MP part of Bundelkhand region (10.75, 5.21 and 22.39% respectively). In Rabi crops the area under gram and pea has increased by 11.27 and 11.45% respectively in the UP part of the region. The districts of southern Bundelkhand have larger area under cereals compared to other districts. In MP part of Bundelkhand region districts like Datia, Tikamgarh, Chhatarpur and Panna have shown increasing trend under fodder crops whereas districts like Damoh and Sagar have shown a decrease in area under fodder crops. The productivity of pea and lentil in the UP part of Bundelkhand region is also higher. Fodder crops are mainly cultivated in Kharif (2%%) followed by Rabi (2%) and Jayad (2%). The number of animals per ha of potential land was 1.37 where as recommended maximum animal density for the type of land found in the region is 0.78 ACU/ha. About 2% land is spared for cultivated fodder making the animals almost dependent on crop residues, which are in deficit. The whole Bundelkhand region may be divided into four zones. The Southern zone is characterized by low animal pressure (0.71-1.0 animals/ha) while the zones in the north has high ratio of animals to land area (1.4 - 2.4 animals/ha). Crop residues of paddy, wheat, coarse cereals, pulses, and sugarcane and groundnut etc. have been estimated and found slight surplus in the UP part and in the MP part of the region but there is severe shortage of concentrate. In the high cropping intensity villages, where crop residue production is more, there is stall-feeding. The number of crossbred cattle in Bundelkhand region was found very less. Both sheep and goat have increased in number. The goat population is more in Chhatarpur. Banda, Hamirpur and Jhansi district. The sheep population is more in Chhatarpur. Tikamgarh. Jhansi and Hamirpur. Villages nearby open forests, wastelands and fallow lands had a high proportion of free range grazing. Small holders and the landless, even in irrigated (high fodder producing) areas, practice free range grazing. There are two systems of grazing in Bundelkhand i.e., Gwari and Chhuita
production potential of animals is low in Bundelkhand. Based on land use, agro climatic conditions, soils and livestock density, the region is divided into four zones for planning the management of agriculture and livestock based production systems:

- It is characterized by low animal pressure, rained cropping and wasteland and free range grazing dominated feeding system. The crop residues, which are the most important source of fodder for stall-feeding, are not enough to support the requirements of the animals. The estimated fodder deficit in the zone is high (46%). The low amounts of feed coupled with the low animal pressure and poor breeds of animal results in a very low milk production in this zone. There is scope for improving forest grazing resources and applying agro forestry for meeting the demands.

- The zone has an estimated fodder deficit of 32%. Major problems of this zone are low animal productivity. Forest degradation. Low crop residue production. Lack of irrigation/water harvesting infrastructure and wasteland rehabilitation. This zone also has scope for activities as recommended in zone 1.

- Zone-3 includes Datia, North Jalaun, North Hamirpur and Banda districts. It is characterized by high animal pressure. Rain fed cropping and a mixed system of stall-feeding and free range grazing on common property resources. The development of food/fodder intercropping systems is being prorogated in the region, which is very relevant to the smallholder. This is surplus zone for crop residues. Added input of green fodder has potential to upscale livestock production. The zone is deficient in wood resources which can be augmented by agro forestry inputs.

- This zone, despite having a high animal pressure, has the highest production of fodder availability per animal for the Bundelkhand but suffering from the same problems of low productive animals, insufficient and low quality green fodder production. Limited market infrastructure for fodder and milk sale and purchase. The problems are lack of improved breed of goats and unorganized goat farmers. Among goat farmers 42.2%, 38.6%, 12.9% and 3.3% are landless marginal, small, medium and large farmer's respectively. Almost 73.3% farmers sale their goats for meat. Farmers considered goat farming as less risk enterprise.
3.2 WHAT IS MECHANIZATION?

Mechanization or mechanization is the process of changing from working largely or exclusively by hand or with animals to doing that work with machinery. In an early engineering text a machine is defined as follows:

Every machine is constructed for the purpose of performing certain mechanical operations, each of which supposes the existence of two other things besides the machine in question, namely, a moving power, and an object subject to the operation, which may be termed the work to be done.

Machines, in fact, are interposed between the power and the work, for the purpose of adapting the one to the other.

In some fields, mechanization includes the use of hand tools. In modern usage, such as in engineering or economics, mechanization implies machinery more complex than hand tools and would not include simple devices such as an ungeared horse or donkey mill. Devices that cause speed changes or changes to or from reciprocating to rotary motion, using means such as gears, pulleys or sheaves and belts, shafts, cams and cranks, usually are considered machines. After electrification, when most small machinery was no longer hand powered, mechanization was synonymous with motorized machines.

3.2.1 FARM MECHANIZATION

Farm mechanization has been defined as the process of development and introduction of mechanized assistance of all forms and at any level of technological sophistication in agricultural production in order to reduce human drudgery, improve timeliness and efficiency of various farm operations, bring more land under cultivation, preserve the quality of produce, improve living condition and markedly advance the economic growth of the rural sector.

Farm mechanization is an important element of modernization of agriculture. Farm Productivity is positively correlated with the availability of farm power coupled with efficient farm implements and their judicious utilization. Agricultural mechanization not only enables efficient utilization of various inputs such as seeds, fertilizers, plant protection chemicals and water for irrigation but also it helps in poverty alleviation by making farming an attractive enterprise.
Traditionally humans and animals were used for field operations and processing activities. As a result of introduction of mechanical powers, the process of farm mechanization began. Adoption of agricultural tools/machinery and other implements provide technology to facilitate agriculture by efficient utilization of inputs, besides reducing drudgery. Traditionally, Indian farmers relied on equipments, which were simple and could be easily fabricated by village craftsmen. Since introduction of mechanical power, agricultural engineering started gaining importance and thus organized professional activities started. It is generally believed that the benefits of modern farm technology have been availed by large farms only. Even farmers with small holdings utilize selected improved farm equipments on custom hiring basis to improve productivity and thus, ultimate increase in quantum of production. Such use of improved farm implements and equipments is preferred with a view to reduce cost of production also.

Agricultural mechanization involves the design, manufacture, distribution, use and servicing of all types of agricultural tools, equipment and machines. It includes three main power sources: human, animal and mechanical with special emphasis on mechanical (tractive power). Farm mechanization is technically equivalent to agricultural mechanization but refers to only those activities normally occurring inside the boundaries of the farm unit or at the farm unit level (example: village, community, co-operatives etc). Tractorization refers to the application of any size tractor to activities associated with agriculture. Motorization refers to the application of all types of mechanical motors or engines, regardless of energy source, to activities related to agriculture.

Agricultural implements are devices attached to, pulled behind, pushed, or otherwise used with human, animal or mechanical power source to carry out an agricultural operation.

Agricultural machinery is a general term used to describe tractors, combines, implements, machines and any other device more sophisticated than hand tools which are animal or mechanically powered. Agricultural equipment generally refers to stationary mechanical devices such as irrigation pump-set.

3.2.2 Impact of Farm Mechanization in the Agriculture

Agricultural mechanization plays an increasingly important role in agricultural production in the Word. It reduces drudgery, increases the safety and comfort of the working environment; it enhances productivity, cropping intensity and production. It increases income for
agricultural workers and then improves social equality and overall living standards. If properly used, it also conserves and properly utilizes natural resources and reduces the cost of production. It allows for timelier farm operations, effectively deals with climate change, produces better quality agricultural commodities, etc.

It is necessary, therefore, to use modern equipment in agriculture and to use modern science and technology to re-invent agriculture. The region needs, inevitably, to accelerate the development of agricultural mechanization.

Resultantly gross food production increased from 50.8 M tons in 1950-51 to 199.3 M tons in 1996-97 and land productivity rose from 0.58 tons/ha/year to more than 2.14 tons/ha/year. From the different studies the following impacts of the mechanization on the agriculture given below.

- That farm mechanization led to increase in inputs on account of higher average cropping intensity and larger area and increased productivity of farm labour.
- That farm mechanization increased agricultural production and profitability on account of timeliness of operation, better quality of work done and more efficient utilization of inputs.
- That farm mechanization increases on-farm human labour marginally, whereas the increase in off-farm labour such as industrial production of tractors and ancillaries was much more.
- That farm mechanization displaced animal power to the extent of 50 to 100% but resulted in lesser time for farm work.

3.2.3 Impact of Farm Mechanization on the Farmers

The effects of the farm mechanization on the farmers are in the form of new seed, fertilizer technology, new cultural techniques of farming, modern farming implements and changes in the timing of operations. Typically, however, improvements in technology also increase the productivity of capital and alter the technological rates of substitution of capital for manpower, reducing the amount of capital that is necessary to replace a unit of manpower at particular levels of output. Other innovations make it possible to reduce the amount of manpower in relation to land needed to produce specified levels of output.
Mechanization affects the coat structure of agricultural production by:

- Saving labour (manual and bullock)
- Easing jobs
- Increasing yield
- Saving land
- Facilitating the opening up of new land
- Conserving natural resources

Most implements and machines bring about several of these effects simultaneously. A tractor, for instance, saves animal and human labour-hours and at the same time makes jobs (e.g., ploughing) easier too. If the tractor actually replaces several draught cattle on the farm, the land formerly needed to grow fodder for the bullocks becomes free for the cultivation of food or cash crops. In regions with scarcity of draught cattle, the tractor facilitates the cultivation of waste land or reduction of fallow land. A threshing machine saves labour hours of bullocks and labourers and decreases loss of grain during the process of threshing. A drilling machine saves seed and increases yield. These examples may suffice to demonstrate the different effects achieved by different machines and implements.

No doubt machines and implements which increase the yield or diminish losses of farm production are desirable not only from the point of view of higher income for the individual farmer but also in the interest of the country as a whole, to increase the food supply for its rapidly growing population. Above implements and machines are available at comparatively low prices or can be used by several farmers on a cooperative basis, they are within the reach even of own cry of small holdings, which constitute the majority of Indian farms. Whereas the quantum jump in production and productivity was brought about by a combination of factors, farm mechanization was often at the centre of controversy due to its impact on employment of human labour in a labour abundant economy.

3.2.4 Some other factors which are responsible to encourage farm mechanization

i) Population of the country is increasing at the rate of about 2.2% per year. Steps have to be taken to arrange food and fiber for such large population by adopting intensive farming in the country. Intensive farming requires machines on the farm.
ii) In multiple cropping programmed, where high yielding variety of seeds are used, all farm operations are required to be completed in limited time with economy and efficiency. This is possible with the help of mechanization.

iii) Farm mechanization removes drudgery of labour to a great extent. A farmer has to walk about 66 km on foot while ploughing 1 ha land once by bullocks with a country plough having 15 cm furrow width.

iv) A large number of females and children work on farm. So, with mechanization females can work at home and children go to school.

v) The proper utilization of basic inputs like water, seeds and fertilizers will be possible with proper equipment.

vi) There are certain operations which are rather difficult to be performed by animal power or human labour such as:

a) Deep ploughing in case of deep rooted crops.

b) Killing the pernicious weeds by deep tillage operations.

c) Leveling of uneven land.

d) Land reclamation.

e) Application of insecticides during epidemic seasons. These operations need heavy mechanical equipment.

3.2.5 Scope of Mechanization

It is quite true that the farmers of developing countries have the lowest earnings per capita because of the low yield per hectare they get from their land holdings. One of the few important means of increasing farm production per hectare is to mechanize it. Mechanization may have to be done at various levels. Broadly, it can be done in three different ways:

I. By introducing the improved agricultural implements on small size holdings to be operated by bullocks

II. By using the small tractors, tractor-drawn machines and power tillers on medium holdings to supplement existing sources.
III. By using the large size tractors and machines on the remaining holdings to supplement animal power source.

As a matter of fact, the progress of the country should be mainly judged on the basis of degree of farm mechanization (production per worker and the horsepower under his command per unit area).

Large amount of labour or draft power, which can be replaced through machines, provides a strong incentive to mechanize. From the energy application point of view, the Indian agriculture is in the transition from:

- Stage 1 (Human Power)
- Stage 2 (Animal Power) to
- Stage 3 and Stage 4 (Power Tiller or Four Wheel Tractor).

### 3.3 FACTORS AFFECTING ON THE FARM MECHANIZATION OR CHALLENGES FOR FARM MECHANIZATION

As increasing demand for industrialization, urbanization, housing and infrastructure is forcing conversion of agricultural land to non-agricultural uses. The scope for expansion of the area available for cultivation is limited. According to agriculture census 2013-14, small and marginal holdings of less than 2 hectare account for 86% of the total operational holdings and 45% of the total operated area. The average size of holding for all operational classes (small and marginal, medium and large) has declined over the years and has come down to 1.08 hectare in 2013-14 from 2.82 hectare in 1970-71 (Anonymous, 2014).

Unlike other agricultural sectors, farm mechanization sector in India has a far more complex structural composition. It is facing various challenges related to farm machinery and equipment, technology, markets, operations, legislation, policy framework and other related areas. Land size, cropping pattern, market price of crops including Minimum Support Price (MSP), availability of labour and cost of labour are the major factors deciding the agricultural mechanization.

These challenges pose a serious impediment to the growth of the industry and agriculture. The key challenges faced by the farm mechanization in India (Mehta and Pajnoo, 2013) are as follows.
(i) The average farm size in India is small (1.08 ha) as compared to the European Union (14 ha) and the United States (170 ha). Therefore, there will be little mechanization unless machines appropriate for small holdings are made available. Due to small size of land holdings, it is difficult for the farmers to own machinery. As a result, the benefits of mechanization are enjoyed by only a section of the farmers who have large farm holdings.

(ii) Mechanizing small and noncontiguous group of small farms is against ‘economies of scale’ especially for operations like land preparation and harvesting. With continued shrinkage in average farm size, more farms will fall into the adverse category thereby making individual ownership of agricultural machinery progressively more uneconomical.

(iii) The major constraint of increasing agricultural production and productivity is the inadequacy of farm power and machinery with the farmers. The average farm power availability needs to be increased to minimum 2.5 kW/ha to assure timeliness and quality in field operations, undertake heavy field operations like sub-soiling, chiseling, deep ploughing and summer ploughing.

(iv) Matching equipment for tractors, power tillers and other prime movers are either not available or farmers make inappropriate selection in the absence of proper guidance, resulting in fuel wastage and high cost of production.

(v) Almost 90 % of tractors are sold in India with the assistance of some financial institution. Sale of farm machinery is driven by factors like financial support, limit of funding (in terms of percentage of the cost), funding/financing institution and the applicant’s profile (deciding the credibility of the loanee).

(vi) The high cost and energy efficient farm machinery are capital intensive and majority of Indian farmers are not able to acquire these assets due to shortage of capital with them.

(vii) Cropping pattern decides the extent of mechanization required for timely operations and achieving optimum results. The scope of mechanization increases with intensive cropping pattern. Price realized by the crop is also an important factor, as it indicates the cash in hand for the farmer.

(viii) Hill agriculture, which covers about 20 % of cultivated land, has little access to mechanization. This situation has to be improved by developing and promoting package of technology for mechanization of hill agriculture to achieve higher productivity.

(ix) There are wide technology gaps in meeting the needs of various cropping systems and regions. The Indian farmers have limited access to the latest equipment and technology.
Further, there is little feedback from the farmers for product improvement and product acceptance.

(x) The quality of farm implements and machinery manufactured by small scale industries in the country is generally not of desired standard resulting in poor-quality work, longer down time, low output and high operational cost. The quality of equipment has to be improved.

(xi) The after sales service of farm machinery is the other concern in India as the majority of farmers are cost conscious. There are inadequate service centers for proper upkeep of the machinery.

3.4 SOURCES OF FARM POWER AND MECHANIZATION:

Various types of agricultural operations performed on a farm can be broadly classified as: Tractive work such as seed bed preparation, cultivation, harvesting and transportation, and Stationary work like silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water.

These operations are performed by different sources of power namely, human, animal, stationary engine, tractor, power tiller, electricity, solar and wind. For doing these operations different types of power available is classified as:

- Human power
- Animal power
- Mechanical power
- Electrical power
- Wind power

A. Human Power

The indications are that the decline in number of laborers employed for agriculture is likely to increase in future resulting a greater investment in labour saving devices and mechanical power. Labour (Human Energy) on Farms: Labour is one of the most important sources of farm power in regions where traditional system of agriculture is practiced. On small farms, high proportion of labour is supplied by the farmer and his family. Only to meet the peak and permanent labour requirements, the hired laborer’s are employed.
On small farm having very little spare capital to buy appropriate type of hand tools and animal drawn equipment, both labour use efficiency and productivity are very low. Labour use efficiency can be improved by engaging labour in a group where sequence of operations demands teamwork for effective output. In the absence of the team, single man would waste other energies, which might result into higher cost of operation. For example, a power thresher operation always demands a team effort for efficient utilization of expensive resources i.e., thresher, cleaner, the prime mover, etc.

**B. Animal Power**

Animal power is the most important source of power on the farm all over the world particularly in developing countries. It is estimated that nearly 80 per cent of the total draft power used in agriculture throughout the world is still provided by animals. Different animal sources are: Bullocks- can pull of about 15% of its weight

The average force a bullock can exert is nearly equal to one tenth of its body weight. But for a very short period, it can exert many more times the average force. Generally a medium size bullock can develop between 0.50 to 0.75 hp.

**C. Mechanical Power**

The third important source of farm power is mechanical power that is available through tractors and stationary engines. The engine is a highly efficient device for converting fuel into useful work. The efficiency of diesel engine varies between 32 and 38 per cent, whereas that of the petrol engine in the range of 25 and 32 per cent. In recent years, diesel engines and tractors have gained considerable popularity in agricultural operations. Small pumping sets within 3 to 10 hp range are very much in demand. Likewise, engines of low to medium speed developing about 14 to 20 hp are successfully used for flourmills, oil expellers etc. Diesel engines of the larger size are used on tractors. Diesel engines are the main source of power in agriculture. The basic reason for their preference is the economy in operation.

**D. Electrical Power**

Now-a-days electricity has become a very important source of power on farms in various countries. It is steadily becoming more and more available with the increase of various river valley projects and thermal stations. The largest use of electric power in the rural areas is for
irrigation and domestic water supply. Besides this, the use of electric power in dairy industry, cold storage, fruit processing and cattle feed grinding has tremendously increased.

E. Wind Power

The availability of wind power for farm work is quite limited. Where the wind velocity is more than 32 km/h, wind mills can be used for lifting water. The most important reason of its low use is its uncertainty. Thus the average capacity of a wind mill would be about 0.50 hp. It is one of the cheapest sources of farm power available.

3.6 FARM MECHANIZATION TOOLS

3.6.1 Tillage and planting machinery

The traditional animal drawn country plough has low output (30-40 h/ha). Tractor drawn MB plough, harrows, cultivators and rotavator are better machinery used by the farmers. There is need for high capacity machines for custom hire services. For precise application of seed and fertilizer, mechanically metered seed drill and seed-cum- fertilizer drill operated by animal and tractor have been developed and are being manufactured to suit specific crops and regions. Zero till drill and strip till drill have also been developed to reduce energy inputs in crop Production. CIAE has developed farm equipment like inclined plate planter and pneumatic planter for precision sowing. Following tools are used for the tillage and plantings of crops

3.5.1.1 Ploughs

A plough is a tool (or machine) used in farming for initial cultivation of soil in preparation for sowing seed or planting to loosen or turn the soil. Ploughs are traditionally drawn by working animals such as horses or cattle, but in modern times may be drawn by tractors. A plough may be made of wood, iron, or steel frame with an attached blade or stick used to cut the earth. It has been a basic instrument for most of recorded history, although written references to the plough do not appear in English until 1100 CE at which point it is referenced frequently. The plough represents one of the major advances in agriculture. There are different types of Ploughs available to match various types of soil structures. These different types are listed below:
- Mould Board Plough
- Disc Type Plough
- Rotary Plough
- Chisel or sub surface Plough
- Sub-soiler Plough

3.5.1.2 Rotavator
A rotavator is a mechanical gardening tool with power blades attached to a spinning surface to plough soil and give optimum tillage. Different rotavator are designed to suit different gardening needs. A gardening rotavator is a compact machine which can be used on any land size but is more appropriate for gardening. Gardeners usually use a variation of this appliance as sometimes, only small flower beds or miniature vegetable patches need to be tilled. Two another rotavator are:

- Frontline rotavator
- The rear line rotavator

3.5.1.3 Land levelers
Land Leveler is significant equipment that is used for farming and agriculture with a purpose to level the land. Land levelers are a great tool in any operations where there is a yard and driveways. Reversible Land Leveler, Terracer Rear or Blade Land Leveler, Heavy Duty Land Leveler and Laser Guided Land Leveler.

3.5.1.4 Cultivators
A cultivator is any of several types of farm implement used for secondary tillage. One sense of the name refers to frames with teeth (also called shanks) that pierce the soil as they are dragged through it linearly. Another sense refers to machines that use rotary motion of disks or teeth to accomplish a similar result. Cultivators are machines in the agriculture industry that are used to break up soil. They are pulled behind tractors using either a three-point linkage or a tractor drawbar. Cultivators are generally used before plows to till the soil and prepare it for the dispersing of seeds and can be used before and after the crops are sowed. They can provide other functions, such as removing and destroying weeds, as well as fertilizing the soil and covering seeds with soil. Different types of cultivators are used in the India which are given below:

- Rotary Cultivator
- Field Cultivator
- Row Crop Cultivator
- Five-tine animal drawn cultivators
- Low wheel cultivator

3.5.1.5 Disc harrows
A disc harrow is a farm implement that is used to till the soil where crops are to be planted. It is also used to chop up unwanted weeds or crop remainders. It consists of many carbon steel and sometimes the longer lasting boron discs, which have many varying concavities and disc blade sizes and spacing (the choices of the later being determined by the final result required in a given soil type) and which are arranged into two sections ("offset disc harrow") or four sections ("tandem disc harrow").

3.5.1.6 Scrapers
Scrapers are the farming machines or tools which are used for the land forming. Some scrapers which are used in Indian agriculture farming are given below:
- Carrier type scrapers
- Rotary scrapers
- Elevator scrapers
- Bottomless scrapers
- Land planes
- Laser controlled drag scrapers

3.5.1.7 Tractor-mounted inclined plate planter
Tractor operated 6-row inclined plate planter is a multi-crop planter for planting of bold and small seeds and developed at CIAE, Bhopal and PAU, Ludhiana. The planter consists of a frame with tool bar, modular seed boxes, furrow openers and ground drive wheel system. It has six modular design seed boxes with independent inclined plate type seed metering mechanism. Seed plates for sowing different seeds can be selected and changed easily. The plate thickness, number and size of cells on seed plate vary according to seed size and desired plant-to-plant spacing. For operation, the seed is filled in the hopper, seeds are picked up by the cells of inclined plate and delivered in the opening connected to furrow opener through seed tubes. Shoe type furrow openers ensure deep seed placement in moist zone for sowing under dry-land condition. Modular seed box-furrow opener units are adjustable for sowing seeds at different row-to-row spacing. The plant to plant spacing can be varied by changing
the transmission ratio. The drive to seed metering mechanism is transmitted from ground drive wheel through chain and sprockets. It can be adopted for sowing intercrop on broad beds. The field capacity of the equipment is 0.42 ha/h with an effective width of coverage of 1.85 m.

3.5.1.8 Furrower
The TNAU, Coimbatore centre has developed a tractor-mounted rotary furrower/trencher. It employs a rotating cutter disc with radial soil cutting blades. The total numbers of blades were 8 with 45º angular spacing in between. The total effective cutting width offered by the set of blades arranged on both sides of the disc, was 300 mm. The staggered arrangement of blades was provided for uniform cutting action on the soil and to avoid excessive impact loads on the shaft carrying the disc. The replaceable blades were mounted on appropriately positioned frog plates. A conventional 8.95 kW rotavator gear box was selected for driving the cutting disc. The gear ratio offered by the selected gear box was 1.7 : 1. The driven shaft’s end carried a chain and sprocket giving a speed ratio of 2.4 : 1, thus providing 200 rpm rotational speed of the cutter disc at a PTO speed of 540 rpm. An idler wheel was provided to tighten the chain drive accordingly.

3.5.1.9 Twin auger digger sugarcane planter
It is a whole stick sugarcane cutter planter and consists of ridger body attached to frame to create furrows, sett cutting unit, fertilizer application unit, chemical application unit, sett covering unit and seed box. The planter is PTO driven and mounted from three point linkage system of a tractor. The cutting of the cane of 350 mm length is done automatically in the machine and setts are treated with insecticides at the cutting point. The sets are placed in the furrow created by ridger bodies with overlapping up to 30%. The pesticide is also sprayed at the ends of sett in the furrows. The sett placed in the furrow is covered immediately after the treatment, the furrow is closed and rows are leveled by the leveler provided in the machine. The field capacity of the machine is 0.20 ha/h.

3.5.1.10 Three-row rotary weeder
A three-row tractor-mounted rotary weeder has been developed at TNAU, Coimbatore centre which consists of four “L” shaped blades per flange. The length of blade is 129 mm with a blade pitch of 46 mm and bite length of 20 mm. The orientation angle of blade is 50º with the horizontal. The design speed of the rotary unit is 200 rpm.
3.5.2 Intercultural and plant protection equipment

Use of long handle wheel hoe and peg type weeder are being accepted as they reduce drudgery and weeding time to 25-110 hours from 300-700 hours in conventional practice. Animal drawn weeder and cultivator are also used for control of weeds. Self propelled and power operated weeder are being increasingly accepted on limited scale. Different designs of low cost hand operated sprayers and dusters are available for application of plant protection chemicals. Low volume and ultra-low volume (ULV) sprayers, which require comparatively smaller quantity of water, are also in use.

These are used to protect the crops from

(a) Weeds and

(b) Pests, insects & disease etc..

They include

(i) Paddy weeder
(ii) Hoes
(iii) Insecticide / pesticide spray pumps of various types, like knapsack sprayers, foot operated / hand operated or engine operated etc.
(iv) Insecticide / pesticide dusters

3.5.3 Irrigation and Drainage Equipment

Diesel and electric pump sets are common. The shift from conventional flood irrigation to sprinkler, micro sprinkler or drip irrigation systems is apparently visible indicating the importance of water use efficiency for covering more area under irrigation. The Government support in the form of subsidy is serving as a catalyst to compensate for the high initial cost of the system.

Importance of drainage for achieving improved productivity is being realized by the farmers and progressive farmers are going for subsurface drainage, which is high initial cost technology. The low-cost mole drainage technology and equipment has been developed for vertisols. The mole drain laying cost is about 70 US$ /ha (4200 INR) and the same is
recovered in one crop season. The farmers are getting attracted in favour of this technology. However, it is just a beginning of adoption of the technology. In years to come, it is expected to be common feature among the farmers. Efforts are on to popularize this technology through demonstrations and awareness programs. Storage of water in ditches are common in the Bihar.

3.5.3.1 Storage of water in ditches

![Image of storage of water in ditches](image)

**Figure 3.2: Storage of water in ditches**

(i) In the area where cucurbits are grown irrigation water facility is not properly available.
(ii) Farmers carry water from small streams and store it in small shallow ditches dug in their field.
(iii) The ditches are duly lined with polythene.
(iv) Water is stored in the ditch and covered with straw to minimize losses due to evaporation in too hot climate.

3.5.3.2 Bamboo boring

- Bamboo boring is widely used in sand silted areas.
- Water table up to 30 – 40 ft.
➢ Major components-MS Flat ring, Bamboo stripe, Nylon net, Nylon rope, GI Steel or PVC pipe.

➢ The length of GI steel or PVC pipe is of 10ft and bamboo pipe is 25 – 30 ft.

➢ Bamboo boring structure is used well with 3 BHP pump.

➢ This may irrigate 2 ha of land with delivery pipe.

➢ The life spam of this boring may go up to 10 yrs.

➢ The cost of boring comes to 2 – 3 thousands

![Figure 3.3.: Bamboo boring (A)](image1)

![Figure 3.4.: Bamboo boring (b)](image2)
Impact of it:

- Area under cultivation of cucurbitaceous crop was almost one to two ha.
- With the implementation of bamboo boring technique the area increased to thirty ha with an increase in the cultivation of cucurbitaceous crop like pumpkin, cucumber, water melon etc.
- Earlier farmers were irrigating 2 ha of their field and rest of the cropped field remained un-irrigated in stress situation, but after using bamboo boring with refinement, more than 20 ha of the area was covered with an increase of crop yield by 25%.

3.5.4 Processing Implements & Equipments

These are used to treat or prepare farm products for use, storage & preservation. The processes included for the purpose are chaff cutting; grain grinding, grain crushing & grain drying etc. The following implements & equipments are generally used in processing of grains

3.5.4.1 Chaff Cutter Machine

This is a fabricate precision engineered chaff cutter machine (table model) which is used in uniform chopping of the fodder for live stock or raw material to agro industries. Our range of product is durable, functionally superior and requires least maintenance and is available in 2 H.P. single phase table model. These are available in the market equipped with electric motor, pulley and belt with following specifications:

Table 3.1: Specifications of chaff cutter machine

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Machine</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overall Width</td>
<td>785 Mm</td>
</tr>
<tr>
<td>2</td>
<td>Overall Length</td>
<td>1400 Mm</td>
</tr>
<tr>
<td>3</td>
<td>Overall Height</td>
<td>1390 Mm</td>
</tr>
<tr>
<td>4</td>
<td>Wheel Diameter</td>
<td>780 Mm</td>
</tr>
<tr>
<td>5</td>
<td>Motor Pulley Diameter</td>
<td>75 Mm</td>
</tr>
<tr>
<td>6</td>
<td>Weight</td>
<td>142 Kgs (Including Motor)</td>
</tr>
<tr>
<td>7</td>
<td>Cutting Blade</td>
<td>High Carbon Steel (2-Nos.)</td>
</tr>
<tr>
<td>8</td>
<td>Bearing Size</td>
<td>6204 &amp; 6206</td>
</tr>
<tr>
<td>9</td>
<td>Blade Size</td>
<td>510 Mm</td>
</tr>
<tr>
<td>10</td>
<td>V-Belt Size</td>
<td>B-102</td>
</tr>
<tr>
<td>11</td>
<td>Electric Motor</td>
<td>1440 Rpm</td>
</tr>
<tr>
<td>12</td>
<td>Capacity</td>
<td>360 Kg/Hr</td>
</tr>
</tbody>
</table>
3.5.4.2 Grain Graders of different Types

Harvested grain (threshed / shelled / dried) needs further processing to get rid of various types of contaminations or undesirable matter, viz., inert material, common and seeds of noxious weeds, other crop/variety seed, decorticated seed, damaged seed and/or off-size seed. Cleaning and grading result in reduced bulk of the material, high value products, safe and longer storage, more out-turn of better quality milled products. The primary method of seed cleaning is the air-screen separator. It uses a combination of air, gravity, and screens to separate seed based on size, shape, and density. These widely-use units come in a variety of models with two to eight vibrating screens. In all cases, the cleaning principles are the same. The grains are fed into the hopper where they are evenly distributed by a feed roller and transferred through a controlled gate on the top sieve. In the process the grains are subjected to primary aspiration by the use of air trunk which drains off chaff, straw, dust or deceased grains. Then the material is passed through sieve layer for separation according to their width and thickness. After the separation, the graded material is subjected to air sifter and aspiration chamber where remaining light particles are sucked off by a strong upward draught of air. The graded material and the impurities are automatically discharged in separate chutes.

3.5.4.3 Sugarcane crushers

Sugarcane juice is the juice extracted from pressed sugarcane. It is consumed as a beverage in many places, especially where sugarcane is commercially grown such as Southeast Asia, South Asia, Latin America and Brazil. The juice is obtained by crushing peeled sugar cane in a mill. According to source of power, the sugarcane crushers shall be of the following types:

a) Animal-driven, and

b) Power-operated.

3.5.4.4 Driers of different kinds

Machines used for drying farm crops are made to a wide variety of designs and many sizes to cover the diverse requirements of different crops. The function of these machines called dryers is simply to remove excess moisture without loss of the quality of the product.
(i) **Batch or Bin dryers**
   a) Flat bed type
   b) Bin type

(ii) **Continuous flow type**
   a) Mixing type (L.S.U.Baffle)
   b) Non mixing type, Recirculatory, RPEC

(iii) **Rotary dryers**
   a) Batch type - Columnar
   b) Bin type - Horizontal

(iv) **Tray type dryers**
   (v) Spray dryers
   (vi) **Freeze dryers**
   (vii) **Electrical dryers**
   (viii) **Solar dryers**
   (ix) **Sack dryers**
   (x) Batch or Bin driers

3.5.4.5 **Paddy Processing machines i.e. Rice Sheller’s**

Rice Sheller’s is an agricultural machine used to automate the process of removing the chaff (the outer husks) of grains of rice. Throughout history, there have been numerous techniques to hull rice. Traditionally, it would be pounded using some form of mortar and pestle. An early simple machine to do this is a rice pounder. Later even more efficient machinery was developed to hull and polish rice. These machines are most widely developed and used throughout Asia where the most popular type is the Engelberg huller designed by German Brazilian engineer Evaristo Conrado Engelberg in Brazil and first patented in 1885.

3.5.5 **Transportation Equipment**

These are used to transport agricultural produce from farm / field to go down or marketplace, they include:

i. Bullock Cart
ii. Trolley for Tractor
3.5.6  Sowing Devices

Drilling is the term used for the mechanized sowing of an agricultural crop. Traditionally, a seed drill consists of a hopper of seeds arranged above a series of tubes that can be set at selected distances from each other to allow optimum growth of the resulting plants. Seed is metered using fluted paddles which rotate using a geared drive from one of the drill's land wheels—seed rate is altered by changing gear ratios. Most modern drills use air to convey seed in plastic tubes from the seed hopper to the coulters—it is an arrangement which allows seed drills to be much wider than the seed hopper—as much as 12 m wide in some cases. The seed is metered mechanically into an airstream created by a hydraulically powered on-board fan and conveyed initially to a distribution head which sub-divides the seed into the pipes taking the seed to the individual coulters.

The following implements are used for sowing various crops:

3.5.6.1 Zero Tillage Seed-cum-Fertilizers drill

It is highly accepted by farmers of Punjab, Uttar Pradesh, Uttaranchal and Bihar after harvest of rice for wheat and vegetable pea crops prevailing in these areas. At 8 centre’s, demonstrations of machine covered 6,691 ha of wheat crop. Sowing is done timely as machine capacity is 4–5 ha/day. Human drudgery is reduced as less number of operations are required. The machine saved Rs 1,000–1,500/ha. The use of machine resulted in 5–6% increase in yield due to early emergence (one week). The machine use was 60–65% cost effective. It saved 60–70% diesel and time of operation. The machine could be used for Bengal gram and pea at NDUAT, Faizabad by replacing furrow openers with those of shovel type.

3.5.6.2 Bed Planters

This machine for bed planting consists of a drive-wheel, fluted, roller-type seed mechanism and shoe-type furrow openers and furrowers for making bed. Its overall dimensions are 2,080 mm × 1,870 mm × 1,350 mm and can be operated with a 35-hp tractor. The machine has cup-feed-type fertilizer metering mechanism. It weight is 270 kg.
3.5.6.3 Potato Planters

It consists of a beltcup-type of metering mechanism with 37 cups, spaced at 60 mm. The holes are provided on the frame for changing ridgers. Its hopper capacity is 140 kg. Machine’s overall dimensions are 1.98 m × 1.83 m × 1.18 and its weight is 250 kg. With this, seed spacing can be changed by changing sprockets provided with the ground-wheel. Machine can be operated with 30-hp tractor. The CCSHAU Hisar centre had conducted trials on the planter, covering 6.2 hectares in Bhatala and Lalpura villages. The seed rate for potato (variety 222) was 3,000 kg/ha and no. of plants per 5-m length were 32.6.

3.5.6.4 Sugarcane Planters

The planting of sugarcane crop is conventionally done through country plough or ridger requiring 30-35 labourers/ha for undertaking various planting operations. These include sett cutting, furrow opening, application of fertilizers in furrows, seed treatment, dropping of cane setts in furrows, application of insecticide, soil covering over the sets in furrows and planking. Non-availability of man power in sufficient number during these days of labour crisis and also planting being a time consuming process, it poses problems before sugarcane growers having 90-92 per cent of the plant area under spring and summer planting. Two types of cutter planters i.e. ridger and disc types, are available. The ridger type cutter planter is used in a well prepared soil while disc type cutter planter can be used immediately after harvest of wheat or rabi crops enabling sugarcane planting 5-6 days earlier than the normal practices. The cutter planter not only obviate 50-60 per cent of the planting operation cost but also enhances the cane yield by 6 to 7 per cent due to proper placement of cane setts, fertilizers and insecticide in the furrows. Impressed with the performance in terms of reduced planting cost and higher yield in the demonstrations, the demand of cutter planter among the farmers is increasing day by day. A few sugar factories particularly the D.S.M. Rauzagaon, Faizabad and Balrampur Sugar Mills, Hydergarh, Barabanki have started planting sugarcane through cutter planter in their sugar mill areas. The Institute is receiving regular supply orders for this implement from many sugar mills and farmers of the country.
3.5.6.5 Paddy Transplanters

The rice planter is mainly comprised of three parts, the motor and the running gear and the transplanter device. The transplanter includes the seedling tray, the seeding tray shifter, plural pickup forks. The seeding tray is like a shed roof where mat type rice nursery is set. When the rice transplanter is brought in the field, the seedlings were fed on the seedling trays. Then the tray shifts seedlings like a carriage of typewriters as pickup forks get seedlings from the tray and put into the ground. The pickup folks act like human figures by taking seedlings from the tray and pushing them into the earth.

Table: 3.2 Specifications of model dimension in different machines

<table>
<thead>
<tr>
<th>Model</th>
<th>AMS-PT-6300B</th>
<th>AMS-PT-8238B</th>
<th>AMS-PT-10238BGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension</td>
<td>2410<em>2132</em>1300mm</td>
<td>2410<em>2165</em>1300mm</td>
<td>2410<em>2645</em>1300mm</td>
</tr>
<tr>
<td>Net Weight</td>
<td>300kg</td>
<td>360kg</td>
<td>410kg</td>
</tr>
<tr>
<td>Diesel engine model</td>
<td>175F Manual Start</td>
<td>175F Manual Start</td>
<td>178F Electric Start</td>
</tr>
<tr>
<td>Diesel engine power</td>
<td>3.68kw/4.93Hp</td>
<td>3.68kw/4.93Hp</td>
<td>4.05kw/5.5Hp</td>
</tr>
<tr>
<td>Diesel engine speed</td>
<td>2600r/min</td>
<td>2600r/min</td>
<td>1800r/min</td>
</tr>
<tr>
<td>Transplanting row</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Row spacing</td>
<td>300mm</td>
<td>238mm</td>
<td>238mm</td>
</tr>
<tr>
<td>Seedling spacing</td>
<td>120/140mm</td>
<td>120/140mm</td>
<td>120/140mm</td>
</tr>
<tr>
<td>Working efficiency</td>
<td>0.2hectare/h</td>
<td>0.27hectare/h</td>
<td>0.24-0.34hectare/h</td>
</tr>
<tr>
<td>Packing size</td>
<td>2250<em>1760</em>600mm</td>
<td>2810<em>1760</em>600mm</td>
<td>2810<em>1760</em>600mm</td>
</tr>
<tr>
<td>Packing weight</td>
<td>360kg</td>
<td>420kg</td>
<td>460kg</td>
</tr>
</tbody>
</table>

3.5.6.6 Tractor drawn multi crop seed cum fertilizer drill

Work: Sowing of small, medium & bold seeds in rows as per recommendation.

Capacity: 1 acre/ hr

Diesel consumption: 3l/ h

Saving of labour: 60%

Saving of cost: 15-20%
Increase in yield: 5-10%

3.5.7 Fertilizing Equipment

Fertilizers are required where soils are deficient in plants food elements. When land is planted food over a long period of years, the plant food element is reduced and yields of crops is lower. Sandy soils lose plant food elements rapidly because they are leached out by heavy rainfall or applications of irrigation water. Some clay soils in low rainfall areas lose plant food elements much more slowly than sandy soil. It is now recognized that higher yields can be expected from most soil in all area if the right type of fertilizers is properly applied.

Fertilizers can be applied to the soil in several forms, such as barnyard manure, granular and pelleted fertilizers of various formulae, and fertilizers in liquid and gaseous form. Special equipment is required for the handling of these type of fertilizers, which are applied to the soil and crop in various way and different stage of culture. For example, barnyard manure is usually broadcast over the land with a manure spreader before seedbed preparation. It is then work into the soil, either by plowing or by disk harrow.

3.5.7.2 Manure spreaders

The manure spreaders are a machine for carrying barnyard manure to yield, shredding it, and spreading it uniformly over the land. This type of machine should be on every farm that produces several tons of manure per year. Manure spreading can be classified as horse-drawn and tractor-drawn types. Horse-drawn manure spreaders as mounted on four wheels and are provided with a tongue and eveners. They are ground-driven.

The mechanism of a ground-driven manure spreader is operated by sprockets and chain from the wheels supporting the spreads. The power or power-take-off-drive from the tractor power takes-off having 548r.p.m. The power take off shaft is telescoping so that it automatically adjusts for the changes in length on turns. The shafts connect to the center of the spreader box. A chain transmits the power to a drive shaft that extends backward along the side of the box to a sealed gear drive connected to the spreader drive mechanism.

The tractor-drawn power-driven spreaders are generally mounted on two rubber-tired wheels on a axle located slightly to the rear of the box, so that the part of that weight of the spreader
will carry by the tractor. The principal parts of the manure spreader are the frame, the box, the conveyor, the beaters, and the widespread.

A. The frame.

Since the manure is very heavy and at least a ton or more is loaded on the spreader for each trip to the field, a substantial yet comparatively light frame is required. The side rails on all spreaders should be made of a good grade of channel steel properly reinforced and braced.

B. The box

The bottom side or the manure spreader box may be made of tongue-and-groove creosoted wood, of marine plywood, or of 12 to 14-gage sheet steel. The side flares of heavy sheet steel. One company used armored steel for the flares to resist damage by blows from the buckets if power loaders. The front of the box is damage by blows inclined end gate, while the rear part of the box is opened to the beaters. The rear end of the box is 1-2 inch wider then front end to reduce pressure on the sides. This also reduces friction as the load move to the rear.

The capacity of a manure spreader box is rated in bushels (by volume), according to a standard formula adopted by the America Society of Agricultural Engineers. Manure spreaders are available in size ranging from 45 to 175 bushels. Some manufactures provide a high side so the box can be converted into a self-unloading or tight forage box.

C. The Conveyor

The manure in the box is moved to the rear by an endless double chain- and-slat conveyor or apron. The angle iron bars used for the conveyor slat are riveted to the chain with the outside leg or high side facing to the rear of the box. The manure is deposited in the box on the conveyor, and then the conveyor moves, it carries the manure with it to the rear of the machine, where it comes in contact with the beaters.

The conveyor operates very slowly. The minimum travel per revolution of the main drive wheel is about 1 inch, while the maximum is about 3 inches. The rate travel is controlled by a lever placed conveniently for the driver. From five to twenty loads can be spread per acre. The tension of the conveyor chain can be adjusted by a setscrew arrangement on each end of the front conveyor shaft.
D. Conveyor Drive:

A ratchet and pawl arrangement is the standard device for driving the conveyor chain of a manure spreader. As the feed cam raises the rocker arm, it causes the feed pawl to engage the teeth on the ratchet wheel and turn it. The number of teeth engaged by the feed pawl at a stroke is regulated by a stop pawl. This in turn regulates the speed of the conveyor and the volume of manure distributed. The adjustment of the feed pawl is controlled by the lever placed conveniently for the driver. The lever is connected to the feed pawl by a long rod and can be shifted to any position without stopping the machine. The power for driving the apron and besters is derived from ground traction of the spreader wheels or from the power take-off of the tractor.

E. The Lower Beater:

The beater is placed just to the rear of the conveyor to beat, tear up, and spread the manure from the rear of the spreader. It must be substantial because it must spread all kinds of manure in various states of physical condition. It should have good strong bearing of the self-aligning or roller type. The beater has steel bars through which the teeth are fastened. Some teeth are riveted in, while other are held in place by nuts.

The beater revolves in the opposite direction to the main wheel. It is, therefore, necessary to have some arrangement to give it this reverse motion, which will be discussed under Beater Drive. The beater should revolve at a comparatively high rate of speed; the ratio is usually about 6 or 7 to 1; that is, a beater revolves about seven times when the main wheel revolves once.

F. Beater Drive:

The chain is the common method of driving the beaters on ground-driven manure spreaders. A large drive sprocket is mounted rigidly on the main axle. The rive chain passes around sprockets on the end of upper beater shaft and the main beater shaft and around movable idler sprocket is lowered, the bottom part of the drive chain is lowered onto the drive sprocket. This will cause the beaters and widespread device to run on the opposite direction to that on the main drive sprocket. The machine is thrown out of gear by raising the drive chain from the drive sprocket. This is done by a control lever placed on the front of the box and connected to the idler sprocket by a rod.
G. The Upper Beater:

Most manure spreader has an upper beater placed above a little to the front of the main beater. This beater aids the lower beater in tearing up and pulverizing the large flakes that are encountered.

H. Widespread Device

To prevent the manure being spread too thickly directly the center of the machine, a widespread device is used. This also spread the manure wider than the machine makes it unnecessary to lap the loads. The device consists of spiral auger-like steel blades. One-half of the spirals are set to throw to the left, while the other half is set to throw to the right. The manure is thrown backward by the beater against the revolving spirals, or which of 7 or 8 feet. The widespread beater is driven by a chain from the main or auxiliary beater shafts.

Some models of manure spreads used only the widespread for beating and spreading the manure. The upper and the lower beaters have been eliminated.

I. Loading The Spreader:

It is considered the better plan to start loading at the front end and finish at the rear end. The manure is turn up and broken to pieces more easily when the load is put on this manner.

J. Mechanical Loaders:

When manure is spread mechanically, more times is consumed in loading than in any other operation. This is also the hardest work. Mechanical loading are available, which eliminate the necessity of loading with a pitchfork.

3.5.8 Rice thresher for small farmers

A 0.5 hp single phase electric motor powered thresher for rice has been developed. It is suitable for small farmers, especially farmers of hilly regions. This thresher operates in hold-on mode. It was evaluated for threshing Kranti variety of rice. With a threshing efficiency of 96–98%, the thresher gave an output of 100–150 kg/h. Labour requirement was observed to be 14–20 person-hours/tone. Initial cost of thresher is estimated to be Rs 8,000 (including Rs 3,000 for motor) and the cost of operation Rs 250–300/tones (including labour charges). Weighing only 45 kg (with motor), it can be easily carried by two persons in the hilly terrain.
3.8.1 High capacity groundnut thresher

High capacity spike tooth type axial flow groundnut thresher (PAU design) was selected for feasibility testing. The thresher consisted of threshing cylinder, concave, cleaning system, a blower and a feeding platform. The modifications included change of concave from perforated GI sheet to MS bar type to reduce thrower loss, increase in the opening size/area of cleaning sieve for free flow of pods and provision to check sieve overflow and bifurcation of air flow to both sieves for better cleaning. Cleaning and threshing efficiency ranged from 96.1 to 99.4% and 97.8 to 99.4%. Broken grain loss was almost negligible but breakage of pods was observed at 300 rpm (less than 1%).

3.8.2 High capacity multi-crop thresher

It was demonstrated at CIAE Bhopal, UAS Raichur, AAI Allahabad and CCSAU Hisar for a total of 325 h for wheat, sunflower, Bengal gram, sorghum, pigeonpea and soybean. CIAE Bhopal centre demonstrated high capacity multi-crop thresher for 160 h. The high capacity thresher was demonstrated among farmers of Allahabad (Uttar Pradesh) and Dharwad (Karnataka) for threshing safflower and redgram. At Dharwad, the thresher gave three times more output than local thresher and it saved 50% labour and time of operation. It reduced human drudgery through saving of time for the same quantum of crop compared to local thresher. The thresher gave clean grain (99%) with negligible grain losses (< 2%).

3.9 Strategy for Mechanization of Indian Agriculture

Agricultural mechanization should contribute to sustainable increase in productivity and cropping intensity so that the planned growth rates in agricultural production are achieved. Mechanization is capital intensive and substantial sums have been invested in our country. In the absence of good planning and direction, investment on mechanization may not yield the expected results. India adopts a policy of selective mechanization under diverse conditions, which makes the agricultural mechanization a challenging task.

An appropriate mechanization technology suiting to the needs of the farmers is required to be adopted. This may be achieved by following a few points as mentioned below.

(i) The widely fragmented and scattered land holdings in many parts of the country need to be consolidated (virtual or real) to give access for their owners to the benefits of agricultural mechanization.
(ii) There is a need to have more interaction among the farmers, research and development workers, departments of agriculture and industry to make farm machinery research and development base stronger.

(iii) To achieve higher production levels, the quality of operations like seedbed preparation, sowing, application of fertilizer, chemicals and irrigation water, weeding, harvesting and threshing will have to be improved by using precision and efficient equipment.

(iv) The rice transplanting operation can be mechanized by introduction of self-propelled walking type rice transplanters on small and medium land holdings. The riding type rice transplanter may be introduced on large size land holdings on custom hiring basis (Mehta and Pajnoo, 2013).

(v) The benefits of agricultural mechanization should be extended to all categories of farmers with due consideration to small and marginal farmers, to all cropping systems including horticultural crops and to all regions of the country especially the rainfed areas.

(vi) There is a need to innovate custom service or a rental model by institutionalization for high cost farm machinery such as combine harvester, sugarcane harvester, potato combine, paddy transplanter, laser guided land leveler, rotavator etc. and can be adopted by private players or State or Central Organizations in major production hubs.

(vii) The high capacity rice combines may be introduced to paddy growing areas on custom hiring basis. It will help in timely harvesting and better yield of paddy crop.

(viii) Medium and large scale farmers may be provided with Govt. subsidies to encourage them to buy and to apply advanced medium and high size machinery such as cotton picker, rice transplanter, sugarcane harvester and combine harvester on their fields (Mehta and Pajnoo, 2013).

(ix) The farm machinery bank may be established for machines being manufactured elsewhere in the country and supply to users/farmers on custom hiring mode.

(x) Provision may be made for special credit support at lower interest rates to rural individuals, venturing into entrepreneurial use of farm machinery through custom hiring (Mehta and Pajnoo, 2013).

(xi) Manufacturing units that are set-up in areas with lower mechanization needs to be supported by extending tax and duty sops. This would result in easier reach of the equipment to farmers in those areas (Mehta and Pajnoo, 2013).

(xii) There is a need for quality manufacturing and after sales support for reliability of farm machinery. This may be achieved by streamlining of testing procedure, training of
engineers and conducting testing of farm equipment for standardisation and quality control in farm equipment manufacturing.

(xiii) There is a need for strengthening training programmes at various levels and for different categories of people on operation, repair and maintenance of agricultural machinery, tractors, power tillers, rice transplanters, combines etc. and for transfer of technology.

(xiv) The quality of life and work environment of farmers/farm women need to be improved. Their work involves considerable drudgery and discomfort. Proper ergonomic designs of agricultural equipment, incorporating latest safety measures and ‘comfort features’ should be made available.

3.10 Methodology Used for Research

Agriculture is not only the source of livelihood but also it generates raw material for the agro based industries which has immense potential in the state. With a view to bring Second Green Revolution in the eastern region of the country (particularly in Bihar) the agricultural activities being undertaken based on ‘Rain God,’ will have to be linked with science.

A strong argument depicting comparative backwardness of the state in regard to Agricultural Mechanization can be its low KW/hectare use of machinery. The same for Uttar pradesh was 1.00 k W/ha. It was much lower than Punjab (3.75 KW/ha i.e., the highest in India and even lower than the national average (1.5 KW/ha. The level of agricultural mechanization was meant for the period 2009-10. As per the execution guidelines of the Agricultural Mechanization Programme/Scheme 2009-10 it was to be launched in all the districts of Uttar Pradesh. The programmed of Farm Mechanization included:

(i) MMA,
(ii) ISOPOM,
(iii) Jute Technology Mini Mission – II,
(iv) NFSM,
(v) RKVY, and;
(vi) State Plan for Promotion of Power Tiller (SPPPT).

Under these six schemes, farmers are provided with the implements, machines and/tools like the following:

(i) Tractor,
(ii) Power Tiller,
(iii) Zero till Seed-Cum-Fertilizer-Drill,
(iv) Raised-bed Planter,
(v) Sugarcane-Cutter Planter,
(vi) Potato planter,
(vii) Potato digger,
(viii) Tractor driven reaper,
(ix) Seed cleaner-cum-grader,
(x) Mobile foot harvester,
(xi) Power weeder,
(xii) Power thresher,
(xiii) Winnower,
(xiv) Cono weeder
(xv) Irrigation pipe,
(xvi) Sprinkler,
(xvii) Pump set (diesel/electric driven),
(xviii) Rotavator,
(xix) Combine harvester,
(xx) wheel-ho,
(xxi) Multi row seed drill,
(xxii) Sprayer duster, and;
(xxxii) Other power driven/human driven agricultural implements, machines, etc.

Subsidy available on Procurement of farm equipments (2009-10)

3.11 RESEARCH DESIGN

The research is a descriptive research. It made use of both qualitative and quantitative tools in analyzing the data gathered through questionnaire, interview etc.

3.11.1 RESEARCH PLAN

Three stage stratified random sampling has been used to draw the sample of farmers in which five Districts were taken as first stage unit, village as second stage unit and farmers as final stage unit. Data were collected from 500 farming families, 100 farmers each from all 5 districts.
3.11.2 Selection of the Farmers

The selection of farmers in all districts was made randomly irrespective of Tehsil, the status of farmers and topography of the village. Thus the survey was conducted with the help of well designed questionnaire (Appendix-B) prepared for this purpose. The data was gathered by personnel interviews of the formers.

3.12 DATA COLLECTION OF FARM MECHANIZATION IN BUNDELKHAND REGION

The research data are collected from different Districts of the Bundelkhand Region by collecting information from the farmers of the villages by taking interviews of them and also filling questionnaire regarding their status of farming. The collection of the data takes place by following:

3.12.1 Primary Sources:

3.12.1.1 Interview-
It is a conversation carried out with a definite aim of obtaining certain information. Interview was designed to gather valid and reliable information through the responses of the interviewee to a planned sequence of questions. Interview took both structured and unstructured forms. That is though content and the procedure involved were designed in advance there were instances where follow up questions not planned for were asked for further clarification.

Interview solved the problem of misunderstanding of questions in the questionnaires. This is because; the interviewer was present to explain any question that the interviewee did not understand.

It is to be stated that the interview method of collecting data was used for this research work. It provided the researcher better understanding of all issues concerning the topic under study. Interviewees practically demonstrated on other issues which were not covered by the questionnaire. For this, fifty farmers were chosen randomly from each districts and conduct observation on them.
3.12.1.2 Questionnaire

This took the form of a list of questions given to respondents to answer with the rationale of getting data on the topic under study. The researcher chose self administered questionnaires as oppose to the postal questionnaires. The questions in the questionnaire took two forms; open ended questions and close ended questions. The close ended questions offered a set of alternative answers from which the respondents were asked to choose the one that most closely represents their view. The open ended questions on the other hand were not followed by any kind of choice. With this, the respondents’ answers were recorded in full. The respondents again answered the questions the way he or she understood them.

It is to be emphasized that questionnaire allowed respondents time to think through the questions to provide accurate answers. The researcher conducted pretesting of the draft questionnaire with few potential respondents in an informal manner before following up with the full scale questionnaire administration.

To check for accuracy, completeness of data and ensure quality, questionnaires and interview guide were numbered serially. Research assistants who retrieved completed questionnaires checked thoroughly to ensure that respondents answered questionnaires.

As an ethical consideration, permission was sought from the various bodies that were involved in the study. The purpose of the study was explained to officials and those who responded to questionnaires and interviews.

3.12.1.3 Personal observation

The researcher undertook personal observation through the agricultural environment of the villages to examine the process of farming, use of farm technology, production of crops and living standard of the farmers who were using farm mechanization. The researcher again visited the different villages of different districts of the district and observed that which types of the technologies used in villages by the farmers.

3.12.2 Secondary Sources

Secondary data are data collected for some other purposes, other than the research in question. Examples of sources of secondary data are encyclopedia, textbooks, magazines,
journals, newspaper, internet, websites and articles. Secondary data is easy to come by, cheap source, already made etc. However, some of its shortcomings are that it may be liable to alterations, it may not be in the required state and it may also be from the wrong source.

This study made use of secondary data very extensively. Some parts in chapter one, three and the whole of chapter two were from secondary data.

3.13 DATA ANALYSIS PLAN

The analysis of the data collected was done at the end of the data collection. The responses were classified and summarized on the basis of the information provided by the respondents. The analysis was done using both qualitative and quantitative tools. With the quantitative tools, the current version of Statistical Product and Services Solution (SPSS) data analysis programmed, Microsoft excel, absolute figures, tables, percentages, and statistical tools such as graphs, charts, maps, diagrams were used, whereas qualitative made use of descriptions, analysis of feedback from interview. The data collected from the farmers of all the 11 districts of the Bundelkhand Region.
CHAPTER – 4

RESULTS AND DISCUSSION

The main objective is the Productivity Growth and adoption of Farm Implements under Farm Mechanization in Bundelkhand region of Uttar Pradesh. The research were conducted for “an study on the status of agricultural mechanization and its need in Bundelkhand region of Uttar Pradesh” in the Department of Farm Machinery Engineering, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad -211007,U.P. (India).

Studies on adoption of farm mechanization in Bundelkhand region of the Uttar Pradesh was conducted in the all seven districts of the region. For this purpose, hundred farmers have been taken randomly from each district villages. The research was done during whole season (both Kharif and Rabi crops). The data obtained from the analysis during the course of investigation has been presented in this chapter and discussed in detail.

As discussed previous chapters that after analyzing the present status of mechanization and practices followed by the farmers of Bundelkhand region, mechanization gap would be identified for the different farm operations to maximize the crops grown in Bundelkhand region of Uttar Pradesh. So as per the mechanization gap this work would suggest the strategies for mechanization in Bundelkhand region to increase the agricultural productivity and it would also develop a model to select the optimum size farm machinery and tractor power and validate it with the help of collected data. This work had been reduced the cost of production when the farm operations were mechanized as it saves labor both human & bullock. In the absence of mechanization, the ever increasing wages rate of human labor & cost of upkeep of draught animals could have increased the cost of production much higher. Further, large cost production means less per unit cost on the farms. Moreover it reduces the risk of non – availability of labor and thus wastage is minimized. Timely marketing was also made possible by quick mechanical transportation, cleaning and Handling.

The first section explains the current position of the farmers of the Bundelkhand region in terms of farm holdings, cropping sequences of major crops and the status of the farm mechanization in the region. Second section studies the factors affecting utilization of farm machinery in Bundelkhand region and third section analyzed the changes in production of crops and livelihood of the farmers after the adoption and implementation of farm mechanization.
This table shows the Estimated contribution of several factors which will be obtained by the farm Mechanization, estimation of the several factor shown in table no. 4.1 respectively

**Table : 4.1 Estimated Contribution of Several Factors**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Estimated Contribution</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Savings in Seeds</td>
<td>15 % - 20 %</td>
</tr>
<tr>
<td>2.</td>
<td>Savings in Fertilizers</td>
<td>15 % - 20 %</td>
</tr>
<tr>
<td>3.</td>
<td>Increase in Cropping Intensity</td>
<td>5 % - 20 %</td>
</tr>
<tr>
<td>4.</td>
<td>Savings in Time</td>
<td>20 % - 30%</td>
</tr>
<tr>
<td>5.</td>
<td>Reduction in Manual Labour</td>
<td>20 % - 30%</td>
</tr>
<tr>
<td>6.</td>
<td>Over – all increase in Farm Productivity</td>
<td>10 % - 15 %</td>
</tr>
</tbody>
</table>

**4.1 Current Status of the Farmers of the Bundelkhand Region**

Rural people of Bundelkhand Region depend upon their livelihood on Agriculture and its allied activities. In pre flood situation (before 2008) affected farmers used to raise the crops Paddy, Wheat, Gram, Vegetables, Jute, and Sunflower etc. After flood the land became barren due to deposition of sand silt and most of the farmers did not able to cultivate their farm field due to lack of agriculture inputs like machineries, suitable soil condition, seeds, fertilizers etc. But many farmers used different agricultural inputs and improved their productivity. The current status of the farmers has been explained as follows.

**4.1.1 Status of Land Holdings of the Farmers (District wise)**

Farm mechanization is as important as any other input for increasing agricultural productivity but land is one of the most important inputs for rural households whose primary means of livelihoods is farming. Land ownership, size and quality are important factors determining agricultural production and economics participation of households.

Apparently, the soils in various districts of U.P. Bundelkhand are poor in N and P availability but medium to high in K availability. Sulphur availability is also marginal to deficient. Among micro nutrients, Zn availability is medium, while other micro nutrients (Fe, Mn, Cu) are at the sufficient level. Taking an overall view, the soils of Bundelkhand region are poor in fertility since their nutrient reserves are being depleted due to crop cultivation, rapid
oxidation of organic matter under desiccating climate and the losses caused through the soil degrading processes.

The following table 4.1.a to 4.1.b summarizes the land holdings of the households of farmers of different districts of the Bundelkhand Region. After the survey of all the districts of the Bundelkhand Region, it was found that maximum farmers (70%) have marginal (less than 1 ha) land holdings and approximately 15% farmers have small (1 to 4 ha) landholdings. Approximately 8.0% farmers have medium (4 to 8 ha) and 7 percent of farmers have large land holdings (greater than 8 ha). After the observation of the table it was found that 03 districts have maximum number of large land holdings and 03 districts have minimum number of large land holdings.

Figure 4.1 explains the distribution of land holdings of Bundelkhand Region. Where: VL – very low, L – low, M – medium, H – high, D- deficient, M+ – marginal, S – Sufficient of the data fertility status shown in table 4.1a, 4.2.b and graphical re- present of the figure no. 4.1 respectively

<table>
<thead>
<tr>
<th>District</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Sulphu</th>
<th>Zn</th>
<th>Fe</th>
<th>Mn</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banda</td>
<td>VL</td>
<td>VL</td>
<td>M</td>
<td>M+</td>
<td>M+</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Chitrakoot</td>
<td>VL</td>
<td>VL</td>
<td>M</td>
<td>M+</td>
<td>M+</td>
<td>M</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Hamirpur</td>
<td>L</td>
<td>VL</td>
<td>H</td>
<td>D</td>
<td>M+</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Jalaun</td>
<td>L</td>
<td>VL</td>
<td>H</td>
<td>D</td>
<td>M+</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Jhansi</td>
<td>L</td>
<td>VL</td>
<td>H</td>
<td>M+</td>
<td>M+</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Lalitpur</td>
<td>L</td>
<td>VL</td>
<td>H</td>
<td>D</td>
<td>M+</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Mahoba</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>D</td>
<td>M+</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

Table 4.1 a: Fertility status of soils in various districts of U.P. Bundelkhand zone

**Table 4.1.b:** Distribution of Holdings by Size Class (%)

<table>
<thead>
<tr>
<th>District/Category of farmers</th>
<th>Marginal (&lt; 1 ha)</th>
<th>Small (1-4 ha)</th>
<th>Medium(4-8 ha)</th>
<th>Large (&gt; 8 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jhansi</td>
<td>81</td>
<td>10</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Lalitpur</td>
<td>63</td>
<td>14</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Jalaun</td>
<td>72</td>
<td>11</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Hamirpur</td>
<td>76</td>
<td>14</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Banda</td>
<td>69</td>
<td>16</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>
All the land holdings has been distributed in two categories, first one is cultivated area which is actual farming field and other one is non-cultivated area or useless farming fields.

The Distribution of cultivated and non-cultivated farming land in different districts of Bundelkhand Region shown in table no. 4.2 and graphical representation figure no.4.

4.1.1.1 Cultivated area
Table 4.2: Distribution of cultivated and non-cultivated farming land in different districts of Bundelkhand Region

<table>
<thead>
<tr>
<th>S.No.</th>
<th>District</th>
<th>Geographical area (ha)</th>
<th>Net area sown (NAS) (ha)</th>
<th>Percent geographical area under crop cultivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jhansi</td>
<td>501327</td>
<td>323287</td>
<td>64.49</td>
</tr>
<tr>
<td>2</td>
<td>Lalitpur</td>
<td>509791</td>
<td>301288</td>
<td>59.10</td>
</tr>
<tr>
<td>3</td>
<td>Jalaun</td>
<td>454434</td>
<td>343574</td>
<td>75.60</td>
</tr>
<tr>
<td>4</td>
<td>Hamirpur</td>
<td>390865</td>
<td>292912</td>
<td>74.94</td>
</tr>
<tr>
<td>5</td>
<td>Mahoba</td>
<td>327429</td>
<td>234003</td>
<td>71.47</td>
</tr>
<tr>
<td>6</td>
<td>Banda</td>
<td>438949</td>
<td>349867</td>
<td>79.71</td>
</tr>
<tr>
<td>7</td>
<td>Chitrakoot</td>
<td>338897</td>
<td>170656</td>
<td>50.36</td>
</tr>
<tr>
<td></td>
<td>TOTAL U.P.</td>
<td>2961692</td>
<td>2015587</td>
<td>68.06</td>
</tr>
</tbody>
</table>

Figure 4.2: Distribution of cultivated and non-cultivated farming land in different districts of Bundelkhand Region

In U.P. Bundelkhand zone, the net area sown (NAS) accounts for 68% of the geographical area with maximum (79.7%) for Banda district and minimum (50.4%) for Chitrakoot district.
4.1.1.2 Soil pattern

All the eleven districts of Bundelkhand Region has sandy soil due to frequent occurrence of flood every year changing soil characteristics. But the quality of the sandy soil has measured in terms of depth of sand deposits in the soil. Depth of sand deposits in the soil has been categorized in three categories i.e. less than 4 inch, 4 inch to 8 inch and more than 8 inch. After the observation of the soil pattern of the soil of different districts, it was found that Pipra block has maximum (70%) area of less than 4 inch depth of sand deposit while Saraigarh block’s soil has maximum (50%) area of up to 8 inch depth of sand deposit. Basantpur block soil has maximum (60%) area of greater than 8 inch depth of sand deposit. The distribution of soil pattern of different districts of the Bundelkhand Region had shown in the table 4.3 and figure 4.3 respectively.

Table 4.3: Distribution of Soil pattern in Bundelkhand Region

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>District/Depth of Sand Deposit</th>
<th>&lt; 4 Inch (%)</th>
<th>Up to 8 Inch (%)</th>
<th>&gt; 8 Inch (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Jhansi</td>
<td>68</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>2.</td>
<td>Lalitpur</td>
<td>20</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>3.</td>
<td>Jalaun</td>
<td>20</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>4.</td>
<td>Hamirpur</td>
<td>60</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>5.</td>
<td>Mahoba</td>
<td>65</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>6.</td>
<td>Banda</td>
<td>68</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>7.</td>
<td>Chitrakoot</td>
<td>50</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>
4.1.1.3 Topography

This zone, the alluvial plains of Kosi, Mahananda and its tributaries and Ganges (narrowstrip in the South) is slightly undulating to rolling landscape mixed with long stretches of nearly flat landscape with pockets of area having sub-normal relief. The area is full of streams with abandoned or dead channels of river Koshi. Its frequent and sudden change of course has left small lakes and shallow marshes. In the south, in between the natural levees of Ganga on the one hand and Kosi and Mahananda on the other, there are vast areas, which remain waterlogged over a considerable period of the year.

4.1.1.4 Rainfall

In Bundelkhand region, the principal source of water is rainfall and hence, it is crucially significant. The normal and the average rainfall for the years 2010-11 to 2014-15 in various districts of Bundelkhand region are given in Table 4.4.

In U.P. Bundelkhand zone, the normal annual rainfall is 871 mm with highest (1044 mm) in Lalitpur district and lowest (800 mm) in Chitrakoot district. And lowest (733 mm) in Panna district. normal and average rainfall given below in the table 4.4 and figure 4.4.
Table 4.4: Normal and average rainfall in various districts of Bundelkhand region

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Districts</th>
<th>Normal rainfall (mm)</th>
<th>Average rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mahoba</td>
<td>850</td>
<td>537.06</td>
</tr>
<tr>
<td>2</td>
<td>Lalitpur</td>
<td>1044</td>
<td>838.79</td>
</tr>
<tr>
<td>3</td>
<td>Banda</td>
<td>845</td>
<td>617.02</td>
</tr>
<tr>
<td>4</td>
<td>Jalaun</td>
<td>862</td>
<td>622.26</td>
</tr>
<tr>
<td>5</td>
<td>Hamirpur</td>
<td>850</td>
<td>785.77</td>
</tr>
<tr>
<td>6</td>
<td>Jhansi</td>
<td>848</td>
<td>590.67</td>
</tr>
<tr>
<td>7</td>
<td>Chitrakoot</td>
<td>800</td>
<td>590.79</td>
</tr>
<tr>
<td>8</td>
<td><strong>Average</strong></td>
<td><strong>871</strong></td>
<td><strong>655</strong></td>
</tr>
</tbody>
</table>

Fig: 4.4 Normal and average rainfall in various districts of Bundelkhand region

4.1.1.5 Education Status of the Farmers

Literacy rate of the Bihar state is very poor due to this the education status of the farmers of the Bundelkhand Region is also not good. Approximately 8% of the farmers of the Bundelkhand Regions are educated below fifth standard while 4% of the farmers are educated from 5th to 8th standard. Approximately 8% of the farmers of the Bundelkhand Regions are educated from 8th to high school standard and 30% of farmers are educated from
high school to 11\(^{th}\) standard while 30% of farmers are educated up to Intermediate class. 15% of the farmers are Graduate while only 5% of them are post graduate. Education standard of the farmers of Bundelkhand Region are shown in the table 4.5, 4.6 and figure 4.5 respectively.

**Table 4.5** Education standard of the farmers in various districts Bundelkhand Region

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Districts</th>
<th>Literacy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mahoba</td>
<td>65.27</td>
</tr>
<tr>
<td>2</td>
<td>Lalitpur</td>
<td>63.52</td>
</tr>
<tr>
<td>3</td>
<td>Banda</td>
<td>66.67</td>
</tr>
<tr>
<td>4</td>
<td>Jalaun</td>
<td>73.75</td>
</tr>
<tr>
<td>5</td>
<td>Hamirpur</td>
<td>68.77</td>
</tr>
<tr>
<td>6</td>
<td>Jhansi</td>
<td>75.05</td>
</tr>
<tr>
<td>7</td>
<td>Chitrakoot</td>
<td>65.05</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td><strong>68.297</strong></td>
</tr>
</tbody>
</table>

**Table 4.6:** Educational standard of farmers in different districts of Bundelkhand Region (%)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Block</th>
<th>&lt; 5(^{th}) Standard</th>
<th>5(^{th}) Standard</th>
<th>8(^{th}) Standard</th>
<th>High School</th>
<th>12(^{th}) Standard</th>
<th>Graduate</th>
<th>Post Graduate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mahoba</td>
<td>9</td>
<td>4</td>
<td>8</td>
<td>32</td>
<td>30</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Lalitpur</td>
<td>8</td>
<td>5</td>
<td>8</td>
<td>30</td>
<td>29</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Banda</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>29</td>
<td>30</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Jalaun</td>
<td>7</td>
<td>3</td>
<td>6</td>
<td>30</td>
<td>28</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Hamirpur</td>
<td>6</td>
<td>5</td>
<td>10</td>
<td>28</td>
<td>31</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Jhansi</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td>31</td>
<td>28</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Chitrakoot</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>28</td>
<td>29</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Averaged</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>30</td>
<td>30</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>
4.1.1.6 Cropping Sequence

Cropping related attributes are presented in terms of distribution of crops (as crop groups) reflective of cropping intensity as well as crop productivity which are the indicators of agricultural growth intensity.

(a) Crop distribution

The gross cropped area is the land area occupied by crops in single-season cropping (kharif or rabi season) and double-season cropping (kharif and rabi seasons). In Bundelkhand region, the crops are grown more commonly in single season (usually in rabi season) and less commonly in double seasons (kharif and rabi seasons). The gross cropped area resulting from such cropping is aptly reflected through cropping intensity.

In Kharif season, the cropping intensity is low, and the pulse and oilseed crop groups make the major contribution to it. The cereal’s contribution to the kharif cropping intensity is generally low, but it is somewhat greater in some districts. District wise cropping sequence of major crops of the Bundelkhand Region (%) in cultivated land shown in table no. 4.7 and figure no. 4.6, 4.7 respectably
Table 4.7: District wise cropping sequence of major crops of the Bundelkhand Region (%) in cultivated land

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Districts</th>
<th>Garma</th>
<th>Kharif</th>
<th>Rabi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Moong</td>
<td>Jowar</td>
<td>Seasmum</td>
</tr>
<tr>
<td>1.</td>
<td>Mahoba</td>
<td>33.25</td>
<td>14</td>
<td>72</td>
</tr>
<tr>
<td>2.</td>
<td>Lalitpur</td>
<td>24.50</td>
<td>20</td>
<td>58</td>
</tr>
<tr>
<td>3.</td>
<td>Banda</td>
<td>52.88</td>
<td>11</td>
<td>70</td>
</tr>
<tr>
<td>4.</td>
<td>Jalaun</td>
<td>38.01</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>5.</td>
<td>Hamirpur</td>
<td>35.79</td>
<td>18</td>
<td>65</td>
</tr>
<tr>
<td>6.</td>
<td>Jhansi</td>
<td>52.81</td>
<td>18</td>
<td>62</td>
</tr>
<tr>
<td>7.</td>
<td>Chitrakoot</td>
<td>51.28</td>
<td>14</td>
<td>68</td>
</tr>
<tr>
<td>12.</td>
<td>Averaged</td>
<td>40.02</td>
<td>14.82</td>
<td>65.28</td>
</tr>
</tbody>
</table>

Figure 4.6: Cropping sequence in Kharif

In rabi season, the cropping intensity is fairly high. Cereals contribute the major share to the rabi season cropping intensity under A group districts, while pulses contribute the major share under Group B districts. Oilseed’s share to the rabi season cropping intensity is much low under both Group A and Group B districts in U.P.
Across the Group A and Group B districts, the overall contributions of cereal, pulse and oilseed crops to the rabi season cropping intensity are 44%, 41% and 3% respectively in U.P. Bundelkhand zone.

![Cropping Sequence in Rabi](image)

**Figure 4.7: Cropping sequence in Rabi**

### 4.1.1.7 Crop Yields

The yields of the major crops in all the eleven districts of the Bundelkhand Regions has been shown in the Table 4.6 and the observation of the yields of different crops has been presented in the table no. 4.8 and Figure 4.8.

**Table 4.8: Block wise productivity (q/ha) of major crops of the Bundelkhand Region**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Block</th>
<th>Garma</th>
<th>Kharif</th>
<th>Rabi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Moong</td>
<td>Jowar</td>
<td>seamsum</td>
</tr>
<tr>
<td>1</td>
<td>Jhansi</td>
<td>11.25</td>
<td>14.39</td>
<td>13.25</td>
</tr>
<tr>
<td>2</td>
<td>Lalitpur</td>
<td>12.58</td>
<td>11.28</td>
<td>13.25</td>
</tr>
<tr>
<td>3</td>
<td>Jalaun</td>
<td>12.78</td>
<td>13.83</td>
<td>13.19</td>
</tr>
<tr>
<td>4</td>
<td>Hamirpur</td>
<td>9.15</td>
<td>10.12</td>
<td>13.17</td>
</tr>
<tr>
<td>5</td>
<td>Mahoba</td>
<td>8.67</td>
<td>7.77</td>
<td>13.25</td>
</tr>
<tr>
<td>6</td>
<td>Banda</td>
<td>9.39</td>
<td>11.79</td>
<td>13.22</td>
</tr>
<tr>
<td>7</td>
<td>Chitrakoot</td>
<td>9.16</td>
<td>10.66</td>
<td>13.28</td>
</tr>
<tr>
<td>8</td>
<td>Avg.</td>
<td>10.26</td>
<td>11.41</td>
<td>13.23</td>
</tr>
</tbody>
</table>
The productivity of various crops in Bundelkhand region is presented in Table 4.8. The state average productivity of the crop is also given for the sake of comparison. While in case of many crops, the crop productivity is lower than the state average, but in case of some crops, particularly the rabi pulse crops, it is either matching or more than the state average under Group A districts of U.P. The productivity of most crops under Group B districts is lower than the state average in Bundelkhand zones. The crop productivity in Group A districts is reflective of the agro-climatic potential of Bundelkhand region to foster higher crop productivity on being provided with appropriate enabling conditions.

4.1.1.8 Irrigation coverage

(a) Percentage of net irrigated area to net area sown in various districts

The percentage of net irrigated area to net area sown is presented in Table 4.6. The data show considerable district wise variation providing scope for categorization of districts as per irrigation coverage. Accordingly, the districts are categorized into higher irrigated (Group A) districts with irrigation coverage over 50% and under irrigated (Group B) districts with irrigation coverage under 50% as indicated below.
Table 4.9: Percent irrigation coverage in various districts of Bundelkhand zones and their categorization into higher irrigated (Group A) and under irrigated (Group B) districts

<table>
<thead>
<tr>
<th>Higher irrigated (Group A) districts</th>
<th>Irrigation coverage (%)</th>
<th>Lower irrigated (Group B) districts</th>
<th>Irrigation coverage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lalitpur</td>
<td>90.84</td>
<td>Banda</td>
<td>47.10</td>
</tr>
<tr>
<td>Jhansi</td>
<td>67.92</td>
<td>Hamirpur</td>
<td>42.76</td>
</tr>
<tr>
<td>Jalaun</td>
<td>63.06</td>
<td>Mahoba</td>
<td>39.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chitrakoot</td>
<td>25.77</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>74.00</strong></td>
<td></td>
<td><strong>39.00</strong></td>
</tr>
</tbody>
</table>

(b) Source wise irrigation coverage in various districts

The source wise irrigation coverage in various districts of Bundelkhand zones is presented for Higher irrigated (Group A) and Under irrigated (Group B) districts in Table 4.7.

In Bundelkhand zone, under Group A districts, close to 50% irrigation coverage is through canal followed by open well and private tube well; whereas under Group B districts, the irrigation coverage largely (60%) is through private tube well and open well.

Table 4.10 Source wise irrigation coverage in various districts (%)

<table>
<thead>
<tr>
<th>District</th>
<th>Canal</th>
<th>Govt. tubewell</th>
<th>Pvt. tubewell</th>
<th>Pond</th>
<th>Open well</th>
<th>Other Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Higher irrigated (Group A) districts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jhansi</td>
<td>42</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>Lalitpur</td>
<td>34</td>
<td>0</td>
<td>24</td>
<td>9</td>
<td>29</td>
<td>4</td>
</tr>
<tr>
<td>Jalaun</td>
<td>66</td>
<td>7</td>
<td>18</td>
<td>1</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>47</td>
<td>3</td>
<td>16</td>
<td>6</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td><strong>Under irrigated (Group B) districts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamirpur</td>
<td>18</td>
<td>14</td>
<td>44</td>
<td>3</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>Mahoba</td>
<td>14</td>
<td>0</td>
<td>5</td>
<td>13</td>
<td>65</td>
<td>3</td>
</tr>
<tr>
<td>Banda</td>
<td>29</td>
<td>9</td>
<td>46</td>
<td>2</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Chitrakoot</td>
<td>12</td>
<td>0</td>
<td>88</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>18</td>
<td>6</td>
<td>46</td>
<td>5</td>
<td>24</td>
<td>1</td>
</tr>
</tbody>
</table>
4.1.1.9 Availability of Farm Machines

Mechanization of farming activities depends much upon the crops grown in the study region and crop-specific requirements of machines in various farming activities. In a state like Uttar Pradesh, where majority of farmers are marginal and crops are grown in fragmented and scattered pattern, extent of use of machines is highly restricted. The economic status, soil quality, etc. also influence the adoption and use of farm machinery. In the Bundelkhand Region, most of the farmers did not have their own machinery equipment. They use to hire the farm machinery and other equipment from the other farmers for their required purpose.

Four major operations such as tillage, weeding, irrigation, harvesting and threshing were identified. After the observation, it found that the farmers of different districts had almost all useful machines available such as ploughs, cultivators, land levelers, rotavator, sickle, threshers, low cost hand operated sprayers and dusters, diesel and electric pump sets and disc harrows.

4.1.1.10 Machines available by own

Bundelkhand Region of Uttar Pradesh state have suffered by drought every year, due to this the financial condition of them was not good. Hence, after the observation of the Bundelkhand Region in terms of ownership of machinery by the farmers. The use of the farm machines in various operations reveals that as much as 80% farmers own animal operated machines for ploughing operations, while 50% farmers own animal operated machines for transportation and marketing. Land preparation, plant protection, harvesting and threshing operations were carried out mostly by manually operated machines and some were use tractor operated machines, which were owned by 9, 40, 90 and 10% farmers respectively. While irrigation operations are entirely carried out using electrical operated machines and pump sets, such machines were owned by only 10% farmers. It should be noted here that only 3% of the farmers own tractors or any other type of machines, though it was found that about 45% of farmers hire tractors for farming purpose. This was particularly because of the fact that owning a tractor requires huge capital investment, which was largely beyond the financially affordable limits of the resource-poor farmers.

4.1.1.11 Utilization of farm machines

It thus comes out that though ownership of expensive machines was fairly restricted among the farmers owing to scarcity of investible finance; they extensively hire-in the machines to
perform various farming operations. As such, ownership and use of machinery was two completely different aspects, especially in case of a highly marginalized economy like Bihar.

In case of time-use of machinery in farming operations, it was observed that human power has consumed the maximum time, especially in harvesting operations of wheat (300 man hours) for one hectare. This is followed by manually operated machines, which consumed more than 317 hours in total on an average, especially in harvesting operations. However, electric powered machines like the tube wells and tractors have consumed very little time as compared to the animal operated and manually operated machines. In particular, while electric tube wells have consumed about 26 hours of usage on an average, the tractors are operated only 6 hours for ploughing and 5 hours for transportation and marketing. In percentage terms, it can be observed that in case of ploughing activity 95 percent of time spent on ploughing is consumed by animal operated machines; while tractor operated machines consume only 5 percent of total time allotted for ploughing. Similarly, in case of transportation and marketing, about 92 percent of total time allotted has been devoted to animal operated machines, while similar tasks are performed by tractor operated machines only in about 8 hours. Now, we have seen earlier that costs on account of animal operated machines and tractor operated machines are comparable and constitute the largest cost components in costs of mechanization.

The utilization of the farm machines in various farm operations has shown in Table 4.11 and the figure 4.9 to Figure 4.19 respectably

**Table 4.11:** Utilization of farm machines in the Bundelkhand Region (percentage)

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Equipment</th>
<th>Kharif</th>
<th>Rabi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land preparation</strong></td>
<td>Deshi Ploughs</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Rotavator</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Cultivators</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Cultivators and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rotavator</td>
<td>70</td>
<td>75</td>
</tr>
<tr>
<td><strong>Harvesting</strong></td>
<td>Sickle</td>
<td>95</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Reaper</td>
<td>05</td>
<td>30</td>
</tr>
<tr>
<td>Land Preparation</td>
<td>Deshi Plough, 20</td>
<td>Cultivator, 60</td>
<td>Rotavator, 50</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Threshing</td>
<td>Threshers</td>
<td>05</td>
<td>100</td>
</tr>
<tr>
<td>Sowing</td>
<td>Manual</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Seed drill and ZTD</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Spraying</td>
<td>Knapshak/ Gator</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Diesel and electric pump sets</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>drip irrigation systems</td>
<td>00</td>
<td>00</td>
</tr>
</tbody>
</table>

Figure 4.9: Farm Machinery utilization for land preparation in Kharif
Figure 4.10: Farm Machinery utilization for land preparation in Rabi

Figure 4.11: Farm Machinery utilization for sowing in Kharif
Figure 4.12: Farm Machinery utilization for sowing in Rabi

Figure 4.13: Harvesting of crops in Kharif
Figure 4.14: Harvesting of crops in Rabi

Harvesting

- Reaper: 30%
- Sickle: 70%

Figure 4.15: Threshing of crops in Kharif

Threshing

- Thresher: 5%
- Manual: 95%
Figure 4.16: Threshing of crops in Rabi

Figure 4.17: Spraying of crops in Kharif
Figure 4.18: Spraying of crops in Rabi

Figure 4.19: Irrigation of crops in Kharif
4.2 Factors Affecting Utilization of Farm Machinery in Bundelkhand Region

As increasing demand for industrialization, urbanization, housing and infrastructure is forcing conversion of agricultural land to non-agricultural uses. The scope for expansion of the area available for cultivation is limited. According to agriculture census 2014-15, small and marginal holdings of less than 2 hectare account for 87% of the total operational holdings and 47% of the total operated area. The average size of holding for all operational classes (small and marginal, medium and large) has declined over the years and has come down to 1.06 hectare in 2014-15 from 2.82 hectare in 1970-71 (Anonymous, 2015).

Unlike other agricultural sectors, farm mechanization sector in India has a far more complex structural composition. It is facing various challenges related to farm machinery and equipment, technology, markets, operations, legislation, policy framework and other related areas. Land size, cropping pattern, market price of crops including Minimum Support Price (MSP), availability of labour and cost of labour are the major factors deciding the agricultural mechanization.

These challenges pose a serious impediment to the growth of the industry and agriculture. The key challenges faced by the farm mechanization in India (Mehta and Pajnoo, 2013) are as follows.
4.2.1 Drought

Every year, Bundelkhand region faces the Drought. After bifurcation of the region, Bundelkhand has become the most drought prone area in the country. Total drought prone area of the Region was 73.06 percent of its total geographical area and 17.2 percent of the total drought prone area in the country. Drought situation was most severe in Group B districts of Region. This was because almost area was covered by hilly region. And the annual rain in this region is very low in comparison to other region of the state.

Due to, hilly area and low rainfall that’s why farmers of the region have suffered most by the drought and the farming operations of them was affected by it. So mechanization of the agriculture in Bundelkhand Region was majorly affected by drought.

4.2.2 Unawareness of farmers towards farm machineries

The literacy rate of the Bundelkhand Region was measured only 58.9% in the census 2011. So mostly farmers are illiterate and due to this they were unaware towards the farm machineries. They have used only old tradition and unaware toward new methods of farming. Matching equipment for tractors, power tillers and other prime movers are either not available or farmers make inappropriate selection in the absence of proper guidance, resulting in fuel wastage and high cost of production. So unawareness of the farmers towards farm machineries is also a major factor which is retarded the farm mechanization growth.

4.2.3 Repair and Maintenance of farm machineries

In the Bundelkhand Region very few farmers have advanced farm machines but the unawareness of the maintenance workshops and the operation of the repair and maintenance they could not maintain their machines. Hence the life and performance of the farm machines would be reduced and it affects on the productivity of the crops.

4.2.4 Poor Economic status of the farmers

The economic status of the farmers of the Bundelkhand Region is very poor because almost 46.8% of rural population of the Bundelkhand Region was living in below poverty line. So they cannot afford the expensive farm machines and also they have not much agriculture fields that’s why they only hire the farm machines when it needed. So farm mechanization is also affected by poor economic condition of the farmers.
4.3 ANALYSIS OF THE CHANGES IN PRODUCTION OF CROPS AND LIVELIHOOD OF THE FARMERS AFTER THE ADOPTION AND IMPLEMENTATION OF FARM MECHANIZATION.

Most implements and machines bring about several of these effects simultaneously. A tractor, for instance, saves animal and human labour-hours and at the same time makes jobs (e.g., ploughing) easier too. If the tractor actually replaces several draught cattle on the farm, the land formerly needed to grow fodder for the bullocks becomes free for the cultivation of food or cash crops. In regions with scarcity of draught cattle, the tractor facilitates the cultivation of waste land or reduction of fallow land. A threshing machine saves labour hours of bullocks and laborers and decreases loss of grain during the process of threshing. A drilling machine saves seed and increases yield. These examples may suffice to demonstrate the different effects achieved by different machines and implements.

No doubt machines and implements which increase the yield or diminish losses of farm production are desirable not only from the point of view of higher income for the individual farmer but also in the interest of the country as a whole, to increase the food supply for its rapidly growing population. Above implements and machines are available at comparatively low prices or can be used by several farmers on a cooperative basis, they are within the reach even of own cry of small holdings, which constitute the majority of Indian farms. Whereas the quantum jump in production and productivity was brought about by a combination of factors, farm mechanization was often at the center of controversy due to its impact on employment of human labour in a labour abundant economy.

4.3.1 Change in economic status of the farmers

After the use of proper farm machines for the different crops by the farmers of the Bundelkhand Region, the production of the crops increases by 10-15% and due to this the economic status of the farmers would be improved.

Table 4.12: Economics of different crops grown in Bundelkhand Region

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Name of the crop</th>
<th>Yield (q/ha)</th>
<th>Cost of cultivation (Rs)</th>
<th>Gross return (Rs)</th>
<th>Net return (Rs)</th>
<th>B:C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seasmum</td>
<td>22.27</td>
<td>23600</td>
<td>36178</td>
<td>12578</td>
<td>1.53</td>
</tr>
<tr>
<td>2</td>
<td>Jawar</td>
<td>36.00</td>
<td>32600</td>
<td>56400</td>
<td>23800</td>
<td>1.73</td>
</tr>
</tbody>
</table>
Relationship between mechanization and agricultural production in various parts of India

Table 4.13: Power availability, cropping intensity, percent irrigated area, fertilizer consumption and grain yield for different states in India.

<table>
<thead>
<tr>
<th>State</th>
<th>Annual rainfall (mm)</th>
<th>% Irrigated area</th>
<th>Power (kW/ha)</th>
<th>Fertilizer (kg/ha)</th>
<th>Cropping intensity</th>
<th>Grain equivalent yield (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>617</td>
<td>40.0</td>
<td>0.71</td>
<td>69.8</td>
<td>1.48</td>
<td>2.01</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>494</td>
<td>13.1</td>
<td>1.61</td>
<td>50.9</td>
<td>1.71</td>
<td>2.40</td>
</tr>
<tr>
<td>Punjab</td>
<td>555</td>
<td>93.7</td>
<td>2.96</td>
<td>299.5</td>
<td>1.80</td>
<td>5.26</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>837</td>
<td>64.7</td>
<td>1.48</td>
<td>150.6</td>
<td>1.49</td>
<td>3.58</td>
</tr>
<tr>
<td>Haryana</td>
<td>494</td>
<td>78.6</td>
<td>2.33</td>
<td>202.5</td>
<td>1.68</td>
<td>3.63</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>421</td>
<td>29.3</td>
<td>0.53</td>
<td>39.2</td>
<td>1.20</td>
<td>0.93</td>
</tr>
<tr>
<td>Assam</td>
<td>1449</td>
<td>27.9</td>
<td>0.56</td>
<td>18.2</td>
<td>1.42</td>
<td>1.61</td>
</tr>
<tr>
<td>Bihar</td>
<td>1024</td>
<td>44.3</td>
<td>0.82</td>
<td>93.5</td>
<td>1.38</td>
<td>1.91</td>
</tr>
<tr>
<td>West Bengal</td>
<td>1355</td>
<td>24.7</td>
<td>1.21</td>
<td>158.9</td>
<td>1.65</td>
<td>3.11</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>1021</td>
<td>25.2</td>
<td>0.71</td>
<td>42.2</td>
<td>1.24</td>
<td>1.38</td>
</tr>
<tr>
<td>State</td>
<td>Code</td>
<td>Tillage</td>
<td>Sowing &amp; Planting</td>
<td>Threshing</td>
<td>Irrigation</td>
<td>Plant Protection</td>
</tr>
<tr>
<td>----------------</td>
<td>------</td>
<td>---------</td>
<td>-------------------</td>
<td>-----------</td>
<td>------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Gujrat</td>
<td>609</td>
<td>31.1</td>
<td>0.90</td>
<td>81.1</td>
<td>1.13</td>
<td>1.08</td>
</tr>
<tr>
<td>Orissa</td>
<td>1123</td>
<td>28.6</td>
<td>0.48</td>
<td>37.7</td>
<td>1.38</td>
<td>1.23</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>920</td>
<td>13.4</td>
<td>0.78</td>
<td>76.6</td>
<td>1.24</td>
<td>1.28</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>594</td>
<td>40.8</td>
<td>1.18</td>
<td>158.9</td>
<td>1.21</td>
<td>1.83</td>
</tr>
<tr>
<td>Karnataka</td>
<td>802</td>
<td>24.9</td>
<td>0.80</td>
<td>90.2</td>
<td>1.15</td>
<td>1.58</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>950</td>
<td>53.6</td>
<td>2.00</td>
<td>135.4</td>
<td>1.21</td>
<td>2.81</td>
</tr>
<tr>
<td>Kerala</td>
<td>1927</td>
<td>19.3</td>
<td>0.86</td>
<td>90.5</td>
<td>1.36</td>
<td>1.45</td>
</tr>
<tr>
<td>Total</td>
<td>880</td>
<td>38.3</td>
<td>1.02</td>
<td>97.6</td>
<td>1.32</td>
<td>1.96</td>
</tr>
</tbody>
</table>

One can better appreciate the Indian farm mechanization scenario by looking at the extent of mechanization of various crop production operations such as seed bed preparation, sowing & planting, weed & pest control harvesting, threshing & post harvest operations. According to the estimates prepared by Ministry of Agriculture, tillage is mechanized to the extent of 37%, sowing and planting 63%, threshing 20%, irrigation 54%, plant protection 43% and harvesting 2%. Hence there is ample scope for further mechanization of Indian agriculture. India is today the largest tractor producing nation of the world with an installed capacity of over 4.79 lakh tractors per year. As many as 2.2 to 2.5 lakh tractors are manufactured and sold in the country every year. Apart from 15 tractor manufacturing firms, there are about 3500 farm machinery manufacturers, over two dozen colleges and departments of agricultural engineering, one Central Institute of Agricultural Engineering at Bhopal, One Central Institute of Post Harvest Engineering and Technology at Ludhiana and four Farm Machinery Training and Testing Institutes located in different parts of the country. All these agencies are engaged in R&D, testing and evaluation as well as commercialization of various types of equipment.
CHAPTER – 5
SUMMERY AND CONCLUSION

In India one is the important sector in any country is Agriculture. This sector is seriously affected by modern technology such as farm machinery, HYV seeds, fertilizers, and pesticides. These types of transitional changes increase the demand of energy in agriculture. At the same time pressure on irrigation sources is increasing to a larger extent due to. This the area underground water irrigation is increasing at faster rate due to unfavorable rainfall conditions, due to which, in Indian agriculture large amount of energy sources is required. In Indian agriculture sector, which should be increased in near future? So present work will focus on the major conclusions. In Indian agriculture there are several factors which will increase the growth performance across the states. This can be find out especially, from Green Revolution in Indian Agriculture. Because in Green Revolution larger amount of inputs is required in production process. But in 294 states, most of the states are not in that position that they can provide the all input factors at larger extent. Due to this reason the disparities are over veiling in different states. In modern agriculture first the focus should be on irrigation because it will provide large amount of water as well as it should be also considered that In recent years, due to unfavorable rainfall conditions the irrigation is affected. The area under irrigation is changing continuously over a period of time. The area which was under canals has been slightly declining, whereas the area under other wells and tube wells were increasing drastically. Use of Energy sources like Diesel and Electricity is increasing day by day at faster rate. For Indian agriculture environment and Indian irrigation system it is the important highlighting feature. Due to this, from 1966 on wards, the demand for energy is increasing continuously when the Green Revolution Program me was implemented in Indian agriculture. At the same time when the area comes under such type of rain fed where rainfall fluctuates, due to unfavorable rainfall conditions, there the most important thing is that, sugarcane demands large amount of fertilizers, as comparing with other crops, next comes to yield per hectare, real cost of production, rate of profit, average net income, labor absorption, and irrigation in sugarcane. On the other hand jowar consumes, low rate of fertilizers, yield, real cost of production, rate of profit, average net income, labour employment, and irrigation. It was 295 observed that labour employment can be improved by cultivating more of sugar cane. And the state scenario is showing that, for farmers point of view sugar cane cultivation is more profitable, next to cotton, rice, and jowar respectively. In all most all the states, sugarcane is showing higher cost of cultivation compared with other
crops, due to high application of inputs with more operational activities. However, with respect to employment, irrigation, and average net income is also very high in case of sugar cane. But at this stage even though sugar cane is much profitable than that of other crops, one should be aware of the availability of water resources, and other input equipment. For that alternative crops should be recommended in order to remove shortage in inputs and avoiding over water use, which is scarce resource in recent years in Indian agriculture. By analyzing the present status of mechanization and mechanization gap in Bundelkhand region, proper strategies will select for the same i.e. farm machinery and tractor power due to which agricultural productivity will be increased.

FUTURE SCOPE

As discussed above agriculture is the main important thing for any country on one side it fulfills the needs of the citizens while on other hand it provides the growth in GDP. So this work will select a proper mechanization and provide a new path to the country by increasing the productivity and improving the efficiency of Inputs such as seeds, chemicals, fertilizers and energy. It will also ensure timeliness of farm operations leading to higher productivity and cropping intensity. In terms of cost, it will reduce the cost of production and agricultural income. Farm mechanization will also reduce the drudgery and improve the safety in operation of farm machinery & help in conserving natural resources i.e. water. In the light of all the points mentioned above it is clear that Farm mechanization plays an important role in the healthy crop stand and in getting production to a beneficial level. Yet the need of time is to overcome the constraints of FM which are acting as a hindrance in its path. This can only be achieved by the cooperation of Government & Private institutes by making excellent policies for the future.

PRIORITY AREAS FOR INDIAN AGRICULTURE MECHANIZATION

Intensification of R & D to introduce energy efficient machines for relatively un-mechanized crops such as cotton, sugarcane, oil seeds, pulses, vegetables & fruits. Use reverse engineering and enforce close collaboration with farm machinery manufacturers. Assist Indian manufacturers in seeking collaboration with well known foreign firms wherever desired engineering technologies are not available.

Intensify research in the area of tractor design engineering due to their extensive use in Indian farming. India is now the largest tractor manufacturer in the world. TMA needs to be involved in this task.
Farm machinery management research to find out use patterns, annual usage, breakdown frequencies, repair & maintenance cost and above all reliability.

Research on safety, comfort, exhaust emissions and health hazards in the use of mechanical power sources and machines needs to be expedited.

Emphasis be laid on conservation farming and energy saving/energy efficient tools and machines.

An area of utmost importance from environmental point of view is proper utilization of about 540 million tones of crop residues available in India. Punjab alone has 10 million tones paddy straw which is mostly burnt. Burning needs to be banned. Appropriate machines for incorporation of residues into the soil, for mulching, for collection, handling & transport for briquetting, gasification, power generation, and/or allied usage is a priority area in the field of mechanization.

Research on alternate engine / tractor fuels including bio-diesel, ethanol, producer gas need to be intensified.

Greater emphasis be laid on design and manufacture of high capacity and precision machines for multi farm use, for corporate/contract farming as well as for custom hiring through Agri. Business Centers being promoted by Govt. of India for the benefit of rural youths.

Equipment for post harvest transport, bulk handling, cleaning grading drying milling packaging and storage are urgently required. These could be imported wherever non-existent. Next revolution in agriculture must be ushered in the area of efficient food processing & agro industries to transform the rural areas & utilize the surpluses. Mechanization packages will be crucial to ensure success of contract/corporate farming.

Mandi mechanization with a view to introduce bulk handling of grains is an urgent need.

Mechanization of hill-agriculture (20% total cultivated area), horticulture and floriculture, forage production and handling equipment, forestry mechanization, and efficient transport equipment are some important areas.

Women-friendly tools and gadgets need to be evolved by modifying the existing ones and designing the new tools to reduce drudgery to women workers.

Mechanization of experimental plots is an important area requiring urgent attention. A mission mode project under the NATP has recently been sanctioned in this area.
- Nearly two-third of the cultivated area is rain fed. Farm power available in these areas is barely 0.3 kW/ha. Hence, mechanization of these areas should be undertaken on priority basis. Large horse power tractors and suitable equipment for conservation of soil moisture, seed bed preparation, seeding/planting, harvesting etc., are required.
- The benefits of farm mechanization have so far remained confined to mainly wheat-based cropping systems. These need to be expanded to all cropping systems including horticulture.
- The present credit policy based on land mortgage is not favorable to small farmers to own mechanical prime movers. It excludes them from the benefits of farm mechanization and supplementing their incomes through hiring out their spare operational capacity. Instead of land mortgage, viability and hypothecation of the machinery may be better criteria.
- There being a positive relationship between power availability and agricultural productivity, power constraint should be removed. An annual growth rate of 4% over 1996 base in power supply to raise it from 1kW/ha to 2kW/ha by 2020 will be adequate to maintain a growth rate of 3% or more in agricultural production. This is based on “power-production relation” studies in India and abroad. The additional power will be supplied by tractors, power tillers, self-propelled machines, engines and electric motors.

For precision farming, precision equipment for planting and plant protection are required.

- Increasing emphasis on Integrated Pest management and Organic farming would require use of efficient cultivation machinery for weeding and hoeing. Research in this area would be necessary to evolve optimum planting geometry and practices.
- Under the WTO regime with liberalization of markets foreign countries might take advantage of dumping their machinery in India, especially such equipment as sugar-cane harvesters, paddy transplanters, potato combines, cotton pickers, horticultural machinery, sprayers unless required equipment are expeditiously developed indigenously and have cost and quality competitiveness. Joint projects by R&D organizations and Indian firms would be
- No Farm Machinery research/development project should be initiated without conducting a market survey to assess the client needs and perceptions.
Greater industry-institution collaboration by undertaking joint research projects and use of reverse engineering would be helpful for speedy development and commercialization of new equipment.

Computer Aided Design (CAD) must be used for optimum design, cost reduction and reliability. All R&D organizations must have a CAD facility with latest design packages. Train R&D engineers to develop proficiency in computer aided design.

R&D engineers must ensure compatibility of their designs with BIS/ISO standards, norms and practices.

Standardization of critical components to ensure quality, durability and interchangeability is essential.

Up gradation of manufacturing technology to upgrade quality and reduce the cost.

It is understood that a proposal is afoot to establish a Farm Mechanization Institute under the auspices of the Ministry of Agriculture and Co-operation. This institute will intensify research on different aspects of Farm Mechanization including techno-socio-economic aspects with a view to develop a long range Farm Mechanization Policy. A Draft Agricultural Mechanization Policy has already been evolved and it awaits approval of the government. Since bulk of tractor and farm machinery manufacturers are located in the northern states of India, it might be desirable to locate such an apex institution in the Punjab, as this state in spite of being one of the most mechanized states in the country, has just one ICAR institute, whereas her neighboring states have 2 to 3 ICAR/central institutes.

To sum up, it may be concluded that farm mechanization is a dynamic technology. It evolves with changes in agriculture in a region/state/country. With diversification of agriculture and adoption of frontier technologies with a view to have eco-friendly sustainable agriculture with globally competitive outputs, cutting edge farm mechanization technologies will need to be developed and introduced expeditiously. Reduction in cost and up-gradation of quality are the twin goals to be achieved. Farm mechanization technology being capital intensive, all farm mechanization R&D projects must be demand-driven and reverse engineering approach must be followed. Up-gradation of manufacturing capabilities, use of computer-aided design and close co-operation with industry through joint projects will help improve the quality and reliability of farm equipment. Conformance to global standards and norms will be necessary. In coming years, higher horse power tractors and high capacity machinery will be required to meet the needs of export oriented agriculture, corporate farming, custom hiring and multi-farm use. Human engineering applications to ensure safety, comfort and compatibility in
respect of noise levels and exhaust emissions will be necessary. The future of farm mechanization in India is bright. However, we will have to intensify research funding and efforts in frontier areas as outlined in this chapter.

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