CHAPTER-1

INTRODUCTION
1.1. Background

Agriculture, in most developing economies, is the core sector providing livelihood to a significant proportion of the population, especially in rural areas. Since this sector faces the largest brunt of underemployment, unemployment, and poverty, a growing agriculture and allied sector is expected to contribute vastly to overall growth and poverty alleviation. Increasing the productive capacity of agriculture through higher land productivity and labour productivity has been an important goal in developing countries. It has been suggested that due to limited scope for expansion of arable land there is need to increase yields to their technically highest levels through appropriate investment in basic infrastructure, human development, and research and extension services.

In India, over 60 percent population is dependent on agriculture for their livelihood. India has 328.7 million hectare of geographical area out of which about 58 per cent is cultivable land. The Net area sown is 140 million hectare and gross cropped area is 192.2 million hectare. The net irrigated area in the country is 63.26 million hectare (2009-10). Agriculture is the mainstay of Indian economy because of its high share in employment and livelihood creation notwithstanding its reduced contribution to the nation’s GDP. The share of agriculture in the gross domestic product has registered a steady decline from 36.4 per cent in 1982-83 to 14.6 per cent in 2009-10 (Economic Survey). Yet this sector continues to support more than half a billion people providing employment to 58.2 per cent of the workforce. It also contributes 10.59% to total export of the country. The food grain production has reached to 218.11 million tones in 2009-10 from 50.82 million tones in 1950-51. It is also an important source of raw material and demand for many industrial products, particularly fertilizers, pesticides, agricultural implements and a variety of consumer goods.

There has been a consistent decline in growth of agriculture sector since 1990 onwards as compared to the 1980s. Numerous policies and programs have
been initiated in Indian economy under the ongoing processes of liberalization and globalization. Economic reforms initiated in India during 1991 have put Indian economy on a higher growth trajectory. Annual growth rate in total gross domestic product has accelerated from below 6 percent during the initial years of reforms to more than 8 per cent in the recent years. The approach paper to eleventh five year plan finds that 8.5 per cent growth in GDP is feasible during the next five years. What now seems more challenging than growth in total GDP, is the sectoral composition of growth, which is related to well being of a very large segment of population. Agriculture which accounted for more than 30 per cent of total GDP in the beginning of reforms failed to maintain its pre-reform growth or keep pace with growth in the non-agricultural sector. On the contrary it witnessed a sharp decline in growth after the mid-1990. This happened despite the fact that agricultural productivity in most of the states was quite low and there was a lot of scope and potential for the growth of agricultural output. Right from the Ninth Five-year plan (1996-97 to 2001-02) onwards, India has been targeting a more than 4 per cent growth rate in Indian agriculture, but the actual growth rate has not turned out to be even half of this target. The poor performance of agriculture against the background of an impressive growth of the overall economy has serious implications. First, it is causing wide disparities between income generated in agriculture and non-agriculture sectors. The slow growth of agriculture would not have caused an increase in disparities, if there was a commensurate decline in population dependent on agriculture. But this is not happening and the population dependent on agriculture is increasing. Second, as more than 50 percent of the workforce and about same proportion of the total population of the country depends on agriculture for income and livelihood, slow growth in agriculture is putting them in distress. The GDP of agriculture increased annually at more than 3 per cent during the 1980s which was considered a reasonably satisfactory performance of the sector. But this pace of growth in agriculture sector couldn’t be maintained subsequently during the process of economic reform in nineties. During 1991, the country initiated economic reforms aimed at far-reaching changes in regulations, fiscal policy, trade policy, exchange rate, role of market forces, private sector participation in economic activities, and government controls and interventions in market. The
agricultural sector was not targeted directly by the reforms for a couple of years, but it was affected indirectly by changes in exchange rate, export liberalization and terms of trade.

Agricultural practices determine the level of food production and, to a great extent, the state of the global environment. In addition to causing the loss of natural ecosystems, agriculture adds globally significant and environmentally detrimental amounts of nitrogen and phosphorus to terrestrial ecosystems, at rates that may triple if past practices are used to achieve another doubling in food production. The detrimental environmental impacts of agricultural practices are costs that are typically unmeasured and often do not influence farmer or societal choices about production methods. Such costs raise questions about the sustainability of current practices

1.2. Sustainable development

The problem of sustainable development has been a matter of great concern among researchers, environmentalists and policy makers since the early –1980’s. In the process it has undergone numerous changes in its definition and objectives. However the most popular definition so far has been the one adopted the World Commission on Environment and Development (WCED). Sustainable development was defined as “sustainable development is development that meets the needs of present without compromising the ability of future generations to meet their own needs” (WCED, 1987). The concept of sustainable development has two dimensions viz, to make better (i.e. development) and to maintain (i.e. sustainability) and the primary focus of sustainability is on the issue of intergenerational equity, which implies equal (or greater) availability of options in terms of human well-being or production prospects to future generation as compared to the present one. Sustainable Development is a multidimensional concept with three interacting angles for natural resource management: ecological security, economic efficiency and social equity (Vasudeva, 2010). Sustainable development does not end with the sustainability of just the environmental and resource system but also requires the sustainability of economic and social system.
All developmental activities, irrespective of their scale, magnitude and nature, have environmental effects – short-term as well as long-term. Although the short-term effects may be negligible as compared to the benefits of the developmental activities, the long-term effects cannot be ignored as they may create serious ecological and environmental problems for which development may not be sustained in the long run.

1.3. Sustainability in Agricultural Development

The word "sustain," from the Latin sustinere (sus-from below and tenere-to hold, to keep in existence or maintain) implies long-term support or permanence. As it pertains to agriculture, sustainable describes farming systems that are "capable of maintaining their productivity and usefulness to society indefinitely. Such systems must be resource-conserving, socially supportive, commercially competitive, and environmentally sound.

Like all developmental activities, agricultural practices also affect the environment. Agriculture not only significantly affects the environment, but is also impacted directly by changes in the environment (Tilman et al., 2002)\(^3\). Apart from the fact that farming activities involve obvious environmental problems, the agricultural sector is the dominant sector in the developing economies. On an average, this sector employs around 70 per cent of the labor force and contributes about 34 per cent to GDP in these economies. Today the main problem in agriculture pertains to sustainability of resources, and indiscriminate use of chemical fertilisers and pesticides. These problems have led to increasing awareness for moving away from the input-intensive agriculture perused during the green revolution phase, to sustainable farming in different parts of the world (Gautam and Bhardwaj, 2011)\(^4\). The widespread concern for degradation and depletion of the natural resource base in the process of growth in agriculture has provoked many to express doubt about the sustainability of such growth. Meaningful farm research practices will address the concept of linking agriculture with environment (Kuriakose & Iyer, 2011)\(^5\).

Sustainable agriculture can be defined as “Agriculture that is productive for the foreseeable future, competitive and profitable, conserve natural resources, protect the environment, and enhance public health, food quality and
safety.” (Kumar & Shivay, 2007)6. Sustainability of agriculture is defined by the Food and Agricultural Organization (FAO) as: “The management and conservation of the resource base and the orientation of technological and institutional changes in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development is environmentally non-degrading, technically appropriate, economically viable and socially acceptable” (FAO, 1991)7. Sustainable agriculture can also be defined as a practice that meets current and long-term needs for food, fibre, and other related needs of society while maximizing net benefits through conservation of resources to maintain other ecosystem services and functions, and long-term human development. According to the consultative Group on International Agriculture Research (CGIAR) “sustainable agriculture is the successful management of resources to satisfy the changing human needs, while maintaining or enhancing the quality of environment and conserving natural resources”. The notion that underlies the definitions of sustainability of agriculture is that growth must be achieved without damaging the natural resource base so that such growth can be maintained in the long run. Sustainable agriculture involves multiculture, intercropping, use of farmyard manure, mulching and application of integrated pest management. If this is followed, there is no reason for the farmers to be threatened and agriculture becomes an economically viable activity, in addition to being environmentally sustainable (Dwarakanath, 2010)8. Addition of organic manure, compost, crop residues, biogas plant spent slurry (biogas manure), vermicompost, etc. help in improving soil fertility and hence the agricultural production can be increased in a sustainable manner (Khandelwal & Rajamani, 2011)9. The ultimate goal or the ends of sustainable agriculture is to develop farming systems that are productive and profitable, conserves the natural resource base, protect the environment and enhance health and safety and do so over the long term. The means of achieving this is low input methods and skilled management, which seeks to optimize the management and the use of internal production inputs (i.e. on farm resources) in ways that provide acceptable levels of sustainable crop yields and livestock production and result in economically viable returns. This approach emphasizes such cultural and management practices as crop rotation and recycling of animal
manure which control soil erosion and nutrient losses and which maintain or enhance soil productivity. Low input farming systems seek to minimize the use of external production inputs such as purchased fertilizers and pesticides wherever and whenever feasible and practicable to lower production costs, to avoid pollution of surface and groundwater, to reduce pesticide residue in food, to reduce a farmers’ overall risk and to increase both short and long-term farm profitability.

The term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

1. satisfy human food and fiber needs;
2. enhance environmental quality and the natural resource base upon which the agricultural economy depends;
3. make the most efficient use of nonrenewable resources and on-farm resources;
4. sustain the economic viability of farm operations; and
5. enhance the quality of life for farmers and society as a whole.

1.3.1. **Sustainability cost of conventional system of farming**

The normal agricultural practices using irrigation, chemical fertiliser, pesticides and high yielding variety of seeds is called conventional agriculture (Jeyakumar, 2011c). With increasing use of chemical fertilisers and pesticides, the conventional agriculture is major source of pollution of inland water bodies and coastal seas. Hence Agriculture profoundly affects many ecological systems. Negative effects of current practices include the following:

1. Decline in soil productivity due to wind and water erosion of exposed topsoil; soil compaction; loss of soil organic matter, water holding capacity, and biological activity; and salinization of soils and irrigation water in irrigated farming areas. Desertification due to overgrazing is a growing problem, especially in parts of Africa.
2. Agriculture is the largest single non-point source of water pollutants including sediments, salts, fertilizers (nitrates and phosphorus), pesticides, and manures. Pesticides from every chemical class have been detected in
groundwater and are commonly found in groundwater beneath agricultural areas; they are widespread in the nation’s surface waters. Eutrophication and "dead zones" due to nutrient runoff affect many rivers, lakes, and oceans. Reduced water quality impacts agricultural production, drinking water supplies, and fishery production.

3. Water scarcity in many places due to overuse of surface and groundwater for irrigation with little concern for the natural cycle that maintains stable water availability.

4. Other environmental ills include that over 400 insects and mite pests and more than 70 fungal pathogens that have become resistant to one or more pesticides; stresses on pollinator and other beneficial species through pesticide use; loss of wetlands and wildlife habitat; and reduced genetic diversity due to reliance on genetic uniformity in most crops and livestock breeds.

5. Agriculture's link to global climate change is just beginning to be appreciated. Destruction of tropical forests and other native vegetation for agricultural production has a role in elevated levels of carbon dioxide and other greenhouse gases. Recent studies have found that soils may be sources or sinks for greenhouse gases.

1.3.2. Measures to maintain sustainability in Agricultural development

Sustainable agriculture depends on replenishing the soil while minimizing the use of non-renewable resources, such as natural gas (used in converting atmospheric nitrogen into synthetic fertilizer), or mineral ores (e.g., phosphate). Possible measures to develop agriculture on a sustainable basis can be taken on two fronts; one related to soil and another related to water.

(a) Soil: Soil performs key ecosystem functions like sustaining biological diversity and productivity; immobilizing and detoxifying organic and inorganic materials; storing and cycling of nutrients and provides support for socioeconomic structure (Mandal & Sarkar, 2011). Soil performs multiple functions to support our ecosystem sustainability. Protecting and nurturing agricultural soils, which are the cornerstone of production, has to be a central feature of sustainability. Throughout the world, agricultural soils have been
degraded by erosion, the build-up of salts and other problems that can only undercut future productivity (Mukherjee, 2011). To preserve the nutrient value of soil, following measures can be adopted.

1. Recycling of crop waste and livestock or treated human manure.
2. Growing legume crops and forages such as peanuts or alfalfa that form symbioses with nitrogen-fixing bacteria called rhizobia.
3. Developing such genetically engineering (non-legume) crops which can form nitrogen-fixing symbioses or fix nitrogen without microbial symbionts.
4. Nutrient-use efficiency is increased by better matching temporal and spatial nutrient supply with plant demand. Applying fertilizers during periods of greatest crop demand, at or near the plant roots, and in smaller and more frequent applications all have the potential to reduce losses while maintaining or improving yields and quality. Such 'precision agriculture' has typically been used in large-scale intensive farming, but is possible at any scale and under any conditions given the use of appropriate diagnostic tools.
5. Multiple cropping systems using crop rotations or intercropping (two or more crops grown simultaneously) may improve pest control and increase nutrient- and water-use efficiency.
6. Agro-forestry, in which trees are included in a cropping system, may improve nutrient availability and efficiency of soil and may reduce erosion, provide firewood and store carbon.
7. Trees and shrubs planted in buffer strips surrounding cultivated fields decrease soil erosion and can take up nutrients that otherwise would enter surface or ground waters.
8. Buffer zones along streams, rivers and lakeshores can decrease nutrient and silt loading from cultivated fields or pastures.
9. Crop pollination can be provided by insects and other animals living in nearby habitats or buffer strips surrounding the cultivated field whereas other organisms from these habitats, such as parasitoids, can provide effective control of many agricultural pests.
(b) Water: In some areas, sufficient rainfall is available for crop growth, but many other areas require irrigation. For irrigation systems to be sustainable they require proper management (to avoid salinization) and must not use more water from their source than is naturally replenished, otherwise the water source becomes, in effect, a non-renewable resource. Improvements in water well drilling technology and submersible pumps combined with the development of drip irrigation and low pressure pivots have made it possible to regularly achieve high crop yields where reliance on rainfall alone previously made this level of success unpredictable. However, this progress has come at a price that the water is being used at a greater rate than its rate of recharge. Several steps, at both policy and management level, can be taken to preserve the water resources. Some of them are followings:

1. improving water conservation and storage measures.
2. providing incentives for selection of drought-tolerant crop species.
3. using reduced-volume irrigation systems, 4) managing crops to reduce water loss.
4. technologies such as drip and pivot irrigation can improve water-use efficiency and decrease salinisation while maintaining or increasing yields.
5. The water-holding capacity of soil can be increased by adding manure or reducing tillage and by other approaches that maintain or increase soil organic matter.
6. Cultivation of crops with high water-use efficiency, and the development through the use of biotechnology or conventional breeding of crops with greater drought tolerance can also contribute to yield increases in water-limited production environments. Investment in such water-efficient technologies, however, is best facilitated when water is valued and priced appropriately.

Thus the sustainable agriculture may be defined as any set of agronomic practices that are economically viable, environmentally safe, and socially acceptable. It is now recognised that sustainable agricultural production not only involves identification and application of improved technologies but also ecological and socio-economic concerns (Pookpkdi, 1993)\(^\text{13}\). If a cropping
system requires large inputs of fertilizer that leak from the system to pollute ground water, drinking supplies and distant coastal fisheries, the system may be sustainable economically as the long-term supply of fertilizer is stable and the economic cost of fertilizer is easily borne by larger grain production but it is not sustainable environmentally or socially, since it does not cover the cost of environmental damage or social costs. The organic agriculture focuses on "living soil", on optimizing the use of biological processes and on avoiding the use of synthetic chemicals and fertilizers. Advocates of sustainable agriculture agree with biological focus and hope to reduce but not necessarily eliminate chemical use. In the context of sustainable agriculture another term "alternative agriculture" has been prominently used. Definition of alternative agriculture sheds much light on operational aspects of sustainable agriculture. Any food or fiber production that has a more thorough incorporation of natural processes, reduced use of off-farm inputs with less harm to environment and consumers, a more productive use of biological and genetic potential of plants and animals, a better match between cropping patterns and the physical capacity of lands and, an improved emphasis on conservation of soil, water, energy and biological resources, is defined as alternative agriculture

The goal of sustainable agriculture is to maximize the net benefits that society receives from agricultural production of food and fibre and from ecosystem services. This will require increased crop yields, increased efficiency of water use, ecologically based management practices, judicious use of pesticides and antibiotics, and major changes in some livestock production practices. The indigenous systems though oriented to resource use with conservation, do not possess high productivity technological components to ensure high use intensity and resource conservation simultaneously. The new science and technology-based interventions have capacity to raise use intensity and productivity of land but they are generally indifferent to conservation considerations. Therefore the goal of sustainability in agriculture can be achieved through blending the positive features of indigenous and modern farm practices (Jodha, 1991)\textsuperscript{14}. Advances in the fundamental understanding of agro-ecology, biogeochemistry and biotechnology that are linked directly to breeding programmes can contribute greatly to sustainability. Also the solution should be
sought not through unproductive conservation but through development with a positive impact on livelihoods which in turn, later become sustainable. Short-term improvements in living thus create conditions for intensive and sustainable human use of environment (Chambers, 1988). Moreover the awareness among the people with regard to environment generated through external forces like NGOs may not be sustainable and have limited influence given the gigantic nature of the problem. Therefore there is a need for stressing the importance of formal literacy programmes and the focus should be on linking the formal system of elementary education with development programmes (Acharya, 1994).

The pursuit of sustainable agriculture will also require substantial increases in knowledge-intensive technologies that enhance scientifically sound decision making at the field level. This can be embedded in physical technology (for example, equipment and crop varieties) or in humans (for example, integrated pest management), but both are essential. However, the challenges of disseminating information on new technologies or on efficient input use and management are enormous, especially in cases where extension programmes are ineffective or completely lacking. The earlier paradigm of science being developed at the international or perhaps national level and then disseminated to farmers should be replaced by an active exchange of information among scientists and farmers. Scientists in developing countries like India who understand the ecosystems, human culture and demands on local agricultural systems must be actively trained, promoted and brought into the international scientific community.

There are limitations in agriculture based developing economies like India to promote environment friendly farm activities. The politicians in the developing countries find it more prudent, given the political instability in most of these countries, to follow populist programmes with visible short-term benefits, than in adopting sustainable and productivity-oriented programmes, whose benefits are less spectacular and future oriented. In other words, as long as employment and income generation problems rule higher on the political agenda, environmental concerns get only back seat in the developing countries (Reddy and Chiranjeevi, 1993). At present the technologies that are most talked about for agricultural sustainability are 'low input intensive agriculture', 'organic farming' or 'natural
farming', etc. Research elsewhere suggests that the low input sustainable agriculture is less productive and less profitable compared to conventional technologies i.e. high chemical fertiliser intensive (Kikuchi 1993; Hsiao 1993; Dobbs 1993). Therefore, the feasibility of these farming practices depends on profitability at the farmer’s level. Unless economic incentives are provided, significant adoption of sustainability measures will not be possible [Hsiao 1993]. Above all, unless people’s awareness, attitudes and perceptions towards environment are changed, sustainable agricultural practices as conceived in the present form appear to be a distant dream (Reddy, 1995).

1.4. **Sustainability in Indian Agriculture**

India can safely be characterized as an agricultural country despite the recent spurt in manufacturing and services and the declining share of agriculture in the national income, since majority of its workforce (about 65%) are still engaged in agriculture and allied activities. It has been the noblest profession in India since the time immemorial and has been carried out on sustainable basis. It is only relatively recent phenomenon that large-scale forest areas, grazing lands and waste lands have been converted into croplands to support the rising population, which has caused ecological imbalance and atmospheric pollution. With no further scope for expansion of agricultural land, efforts have been made to enhance the production of food grains using high-yielding variety of seeds, fertilizers and irrigation along with advanced farm equipments called as green revolution in India. Though there were widespread acknowledgement regarding the green revolution's role in boosting foodgrain output in India (at least in its initial phase), doubts were growing regarding its cost-effectiveness and sustainability(Rao, 1983; Nadkarni, 1988). While green-revolution agriculture addressed mainly productivity issues, sustainable agriculture must not only address productivity issues more intensively, but do so keeping multidimensional (economic, environmental and social) concerns of sustainability in sight (Rao & Rogers , 2006). Apart from this, so-called green revolution is confined to a few crops, viz, wheat, rice and maize and has been possible only in restricted areas, i.e., Punjab, Haryana and Western Uttar Pradesh and certain selected districts of Andhra Pradesh, Maharashtra and Tamil Nadu.
Naturally much work is needed to lift the agriculture to a level where it is least affected by vagaries of monsoon and needs little from outside the farm, i.e., lesser dependence on chemical fertilizers and water. The limited success of green revolution has been a mixed bag in that it has given rise to new set of problems: overuse of water and fertilizers. Excessive use of water results in water logging and salinization whereas excess of fertilizers and pesticide cause pollution of water bodies and contamination of ground water. India has the largest area of irrigated land (61.71 million hectares,) of which about one-third land is already degraded and 7 million hectare have been abandoned. In such a situation a renewable and lasting alternative, sustainable agriculture, has to emerge for successful agricultural revolution (Jeyakumar, 2011)\textsuperscript{25}.

The issue of sustainability of Indian agriculture has attracted attention due to, among other things, the observations that in recent years, the growth rates of output and productivity of a number of crops have been falling in several regions (particularly in the Green revolution regions) of the country and the profitability of farming has started declining leading to abandonment of farming on an increasing scale. It means that despite the impressive growth achieved by Indian agriculture following the green revolution, instability too has shown a tendency to rise (Mehra, 1981\textsuperscript{26}; Hazell, 1982\textsuperscript{27}; Nadkarni and Deshpande, 1982\textsuperscript{28}; Rao, et al, 1988\textsuperscript{29}). These phenomena have often been explained in terms of adverse effects of the new irrigation – fertilizer based High Yielding Variety (HYV) – technology introduced in the mid 1980s. Most of the green revolution regions have reached a plateau in productivity, and profitability of farming has started falling, though these regions still continue to be highly productive compared to other regions and hold the key for meeting future food demands (Vyas and Reddy, 1993)\textsuperscript{30}. Moreover, the high productivities achieved in green revolution regions are observed to be unstable and fluctuating (Mahendra-dev, 1987\textsuperscript{31}; Mitra, 1990\textsuperscript{32}). Besides, the failure to realise the link between poverty and environmental sustenance has further aggravated the problem. In fact, it is argued that properly conceived poverty alleviation programmes could be a step in the direction of environmentally safe world (Vyas, 1991)\textsuperscript{33}.

The issue of sustainability in Indian agriculture can be analysed across three dimensions: ecological, economic and social, which are as follows.
1.4.1. Ecological sustainability

Many traditional and most conventional farm practices are not ecologically sustainable. They overuse natural resources thereby reducing soil fertility, causing soil erosion and contributing to global climatic change. Sustainable agriculture has several major advantages over both traditional and conventional practices. It has following ecological dimensions.

(a) Soil fertility: A continuous fall in soil fertility is a major problem in many parts of India. Sustainable agriculture improves fertility and soil structure and prevents erosion, so would be an answer to this problem.

(b) Water: Irrigation is the biggest consumer of fresh water, and fertilizer and pesticides contaminate both surface- and groundwater. Sustainable agriculture increases the organic matter content of the topsoil, so raising its ability to retain and store water that falls as rain.

(c) Biodiversity: Sustainable agricultural practices frequently involve mixed cropping, so increasing the diversity of crops produced and raising the diversity of insects and other animals and plants in and around fields.

(d) Pollution: Pesticides are hazardous to human health as well as to the local ecology. Incorrect handling, storage and use of pesticides lead to health and pollution problems. Sustainable agriculture reduces or eliminates the use of hazardous chemicals; instead it controls pests with a variety of biological and agronomic measures and the use of natural substances.

(e) Landscape: Agriculture and forestry clothe the rural landscape. Inappropriate use of land causes erosion, landslides and flooding, clogs irrigation channels, and reduces the ability of the land to support the local population. Impoverished rural people flock into the cities in search of jobs, forming unsightly, insanitary slums that further destroy the landscape. Rehabilitating ecologically damaged areas needs huge investments that few countries can afford. Sustainable agriculture avoids these problems by improving productivity, conserving the soil, avoiding the expansion of farming into unsuitable areas, and preserving rural jobs.

(f) Climate: The way agriculture is practiced contributes significantly to global climatic changes. Conventional agriculture contributes to the production of greenhouse gases in various ways: by reducing the amount of carbon stored in the
soil and in vegetation, through the production of methane in irrigated fields, and through energy-intensive activities such as the production of artificial fertilizers. Adopting sustainable agriculture would reduce these impacts significantly.

1.4.2. Economic sustainability

Agriculture cannot be sustainable unless it is economically viable over the long term. The conventional agriculture poses greater long-term economic risks than "sustainable" alternatives in following perspectives.

(a) Export vs. local orientation: Governments tend to view export-oriented production systems as more important than those that supply domestic demands. This is misguided. Focusing on exports alone involves hidden costs: in transport, in assuring local food security, etc. Policies should treat domestic demand and in particular food security (either by farmers producing food for themselves, or by selling produce for cash they can use to buy food) as equally important to the visible trade balance.

(b) Debt: The Green Revolution raised India's grain output significantly, but a vast number of small-scale farmers ran into a debt trap: they took out loans to raise their production, and then found that they could not pay the money back. A large number of those farmers were so desperate that they committed suicide.

(c) Risk: Concentrating on specific commodities seems to promise high economic returns. But market production implies certain risks: international agricultural prices are dropping and so cheap foreign food may sweep into the national market, leaving Indian farmers without a market. As a World Trade Organization signatory, the Indian government is under pressure to deregulate and open its economy to the world market so cannot protect its farmers behind tariff walls.

(d) Niche markets: Organic agriculture is one of the strongest ways to farm in a sustainable way. The demand for certified organic products is increasing quickly, opening opportunities to expand sales of such products and to explore niche markets.

(e) Employment: Farming is the main source of employment for rural people. Trends towards specialization and mechanization may increase narrowly measured "efficiency", but they reduce employment on the land. Sustainable
agriculture, with its emphasis on small-scale, labour-intensive activities, helps overcome these problems.

1.4.3. Social sustainability

The social sustainability of farming techniques is related to the following ideas of social acceptability and justice.

(a) Inclusiveness: Development cannot be sustainable unless it reduces poverty for the broad masses of people in India. The government must find ways to enable the rural poor to benefit from agricultural development.

(b) Political unrest: Gaps between the "haves" and "have-nots" feed a feeling of social injustice among those who feel neglected and excluded from development opportunities, as well as from better-off sympathizers. As a result there would be a climate favorable to political opposition and even violence.

(c) Local acceptance: Many new technologies fail because they are based on practices or assumptions from outside. Sustainable agricultural practices usually are based on local social customs, traditions, norms and taboos, so local people are more likely to accept them and adapt them to their own needs.

(d) Indigenous knowledge: Sustainable agricultural practices often rely on traditional knowhow and local innovation. Local people have a wealth of knowledge about their environment, crops and livestock. They keep locally adapted breeds and crop varieties. They have social structures that manage and conserve common resources, help people in need, and maintain the social fabric. Rather than ignoring or replacing this knowledge, sustainable agricultural development seeks to build on it and enrich it with appropriate information from outside.

(e) Gender: In traditional agriculture, women traditionally bear the heaviest burdens in terms of labour. In modern conventional farming, too, men often benefit the most: they control what is grown and how the resulting income is spent. Sustainable agriculture attempts to ensure that the burdens and benefits are shared more equitably between men and women.

(f) Food security: Traditional farming techniques often fail to produce enough food, or enough variety of food for a balanced diet. Conventional modern farming focuses on a few commodities, so people still do not have a balanced diet. Sustainable agriculture improves food security by improving the quality and
nutritional value of the food, and by producing a bigger range of produce throughout the year.

(g) Participation: Traditional society in India is riven by wealth and caste distinctions. Introducing conventional farming innovations tends to exacerbate these: the rich and higher-caste tend to benefit, while the poor and lower-caste are left out. Sustainable agricultural interventions consciously target the less well-off, and empower them so they can organize and speak with their own "voice", so promoting dialogue and democracy.

The relative values that people place on different trade-offs between these three dimensions vary over time and place. Achieving a balance between them is one of the greatest challenges to operationalising the concept of agricultural sustainability in India.

In order to ensure sustainability of Indian Agriculture –The National Policy on Agriculture (GoI, 2000)\textsuperscript{34} gives special emphasis on following facts – utilization of vast and untapped growth potential of Indian Agriculture; strengthening the rural infrastructure to support fast agricultural development; promotion of value addition and to accelerate the growth of agriculture based business; creation of employment in rural areas; securing a fair standard of living for the farmers and agricultural workers including their families; discouraging migration to urban areas; and facing the challenges arising out of the Economic Liberalization and Globalization. According to India’s Agricultural Policy (2000)–The Agriculture which is based on “technically sound, economically viable, environmentally non-degrading and socially acceptable use of natural resources – land, water and genetic endowment” etc. is called as Sustainable Agriculture. In other words – farming systems and practices that maintain or enhance the economic viability of agricultural production, the natural resource base, and other systems which are influenced by agricultural activities, may be called as Sustainable Agriculture.

Under the programme of Sustainable Agriculture, the Government of India, accords abiding importance for improving the quality of country’s land and soil resources through a number of national programmes. The Government is inclined to promote the rational utilization and conservation of its water resources, and to offer highest priority to the conjunctive use of surface and
ground water. According to the policy, the use of biotechnology will be promoted for evolving plants that consume less water, are drought resistant, pest resistant, contain more nutrition, give higher yields and are safe in view of environment. Balanced and conjunctive use of bio-mass, organic and inorganic fertilizers and controlled use of other agro-chemicals through integrated nutrient and pest-management is to be promoted to achieve the sustainable increases in agricultural production.

According to the Policy Document of Indian Agriculture Policy, Agriculture in India is a way of life, a tradition, which, for centuries, has shaped the thought, the outlook, the culture and economic life of Indians. Therefore agriculture in India is central to all strategies for its planned socio-economic development. A fast agricultural growth is essential in order to achieve self-reliance, household food security; and in order to bring about equity in distribution of income and wealth that may result into a fast reduction in poverty levels.

For sustainable agriculture, the Indian National Agriculture Policy has fixed following aims to achieve within a period of twenty years-

1. A Growth Rate in Excess of 4 percent per year in the agriculture sector;
2. The growth in agriculture should be based on efficient use of resources and conservation of soil, water and biodiversity;
3. Agricultural growth must be equitable i.e. it must be widespread across regions and farmers;
4. The agricultural growth should be demand-driven growth, and it should cater to domestic markets and should maximise benefits from export of agricultural products in the face of challenges arising from economic liberalization and globalization;
5. The agricultural growth should be technologically, environmentally and economically sustainable.

The 11th Five Year Plan document (Planning Commission, 2008) further emphasizes the pressing need to pursue accelerated agricultural growth that must not be at the cost of sustainability of our natural resource base that is limited and compounded by widespread degradation of soil and exploitation of groundwater. Action on the environmental front cannot wait especially in the face
of looming adverse impacts of climate change resulting from global warming. Increasing subsidies on fertilizers, per se, have further contributed to natural resource degradation. Thus far, research has focused on increasing the yield potential through more intensive use of water and chemical inputs. Far too little attention has been given to long term environmental impact or on methods or practices of efficient use of inputs for sustained agriculture.

National Mission for Sustainable Agriculture (2007) formed under the National Action Plan on Climate Change (NAPCC) will focus on areas critical to agriculture in adapting to climate change. Some of the priority actions include:

1. Development and promotion of improved technologies to conserve soil and water, and development of stress resistant crop varieties (using biotechnology tools)
2. Enabling farmers for adoption of relevant technologies, developing and promoting improved management strategies for improved use-efficiency of inputs and reduced greenhouse gas emissions
3. Strengthening information sharing and dissemination mechanisms amongst farming communities
4. Strengthening of database and sharing/access mechanisms at different levels on land use, soil and water resources, resource degradation, socio-economic features and agro climatic variables.

NAPCC recognizes and lays stress on the need to enhance the quality and quantum of human resource that is a prerequisite to resolve increasingly complex issue of agricultural sustainability that are emerging on account of climate change.

1.5. Importance of Agriculture in Uttar Pradesh

Uttar Pradesh (UP) is situated in northern part of India and is surrounded by Bihar in the east, Madhya Pradesh in the south, Rajasthan, Delhi, Himachal Pradesh and Haryana in the west and Uttarakhand in the north. Geographically it is situated in one of the most fertile tracts of the country i.e. Ganga and Yamuna basin. Its population of 19.96 crores (census 2011) is 16% of the country but occupies only 7.36% of the total area of the country. Total geographical area of the state is 24,170 thousand hectare (which is 7.33% of total area of India) out of
which 16,573 thousand hectare is under cultivation. Gross cropped area is 25,414 thousand ha with the cropping intensity of 153%. The total irrigated area of state is 130.85 Lakh Hectares during the year 2010-11. The source wise Irrigation status in the state shows that canal irrigation is 18.02%, State Tube well irrigation is 3.01% and Private tube wells have maximum share of irrigation that is 70.17%.

Paddy and Wheat are the most important crops of the State. Uttar Pradesh is largest producer of wheat, potato, sugarcane and milk whereas third largest producer of rice in the country. The maximum area in the state is being used for cultivation of food grains of which only 13.8% is covered under pulses. Approximately 79.8% of the gross cropped area is devoted for the production of food grains. Other important crops grown in the State are sugarcane, potato, mustard, groundnut, gram, pea and lentil. The sunflower and soybeans have also been introduced successfully in the State during past. Uttar Pradesh is also a major producer of fruits & vegetables. It has considerable potential to increase the productivity and production of fruits, vegetables, spices and flowers on account of the varied agro climatic conditions, abundance of natural resources and introduction of technological changes. It is the prominent sugar cane producing state in the country. Area under sugar cane in the state is highest amongst all the states, which is 42.50% of the total cane area of the country. From the viewpoint of total sugar production it is on the second among all states of the country. In total cane crush of the country, it contributes 26.82%.

In Uttar Pradesh size of holding is around 0.83 ha and per capita land area is 0.14 ha, which is less than a half of the national average of 0.32 ha. Composition of the farmers of the State shows that there are 90% farmers are hailing from marginal and small category. Most of the farmers are just above the poverty line or below the poverty line. It means a large section of farmers are economically marginal and their purchasing power is much poor.

Uttar Pradesh has approved a new Agriculture Policy for the state, envisaging 4% agriculture growth rate. To achieve this, Agriculture Policy revolves around implementation of activities based on seven thrust areas, called Sapta Kranti, viz. extension, irrigation and water management, soil health and fertility, seed management, agriculture marketing, mechanization, agriculture research and diversification. In 12th five year plan, implementation of a new
Agriculture Policy is under consideration for achieving 5 percent agriculture growth rate.

In order to foster the rapid growth of agriculture in the state Agricultural Universities and other agencies are involved in the development of new techniques for the benefit of farmers and improvement in crop production. For the dispersion of new technology amongst the farmers, Agriculture Technology Management Agency has been set up in 70 districts of U.P. and proposed to cover the entire state in future. Under the agricultural extension programme the Krishi Vigyan Kendra/Krishi Gyan Kendras have been established in the various districts under agriculture university of the state which carry out extension activities by organizing training, demonstrations, farm advisory services, kisan mela and kisan gosthis. At present 67 KVKs are established in the state out of which 49 KVKs are established under SAUs, 05 under ICAR Institutes and 13 under NGOs and other organizations. In addition to above, the KVKs also carried out seed production programme, fisheries, production of bio-fertiliser and bio agents for control of crop pests and distributed among the farmers.

Agriculture still constitutes the backbone of the state economy, more so, because it provides livelihood to about two-third population of the state. It produces not only sufficient food grains for the sustenance of its population but also fulfills the food grains requirement of other states and generate a surplus for export as well. The state is endowed with ample alluvial soil along with diverse agro-climatic profile which can support the cultivation of variety of crops. Due to large cultivated area, its share in national agricultural production is quite impressive but low crop productivity has hindered the realisation of ultimate potential.

1.6. Scope of the Study

Uttar Pradesh is the most populous state in India. Uttar Pradesh can be divided into four regions (1) Western, (2) Eastern, (3) Central and (4) Bundelkhand regions. The state is divided into 18 divisions and 75 districts. Uttar Pradesh is the largest producer of food grains and oil seeds in the country. It leads all the states in India in the production of wheat, maize, barely, gram, sugarcane and potatoes. Recently the organized industrial sector of Uttar Pradesh was
confined to agro based industries such as sugar, cotton, textiles, edible oils, miscellaneous food preparations, paper etc. For the coordinated and rapid economic development, emphasis is being laid on village oriented and agro-based small industries like handlooms – silk and others.

Therefore, due to this central importance of the state in the scene of Indian agriculture, a case study of Uttar Pradesh in relevance of sustainable agricultural development in India is taken in the present study. The growth of agriculture in Uttar Pradesh will eventually lead to the growth of agriculture at national level and also the growth of Indian economy. The analysis of various factors affecting the agriculture sector in UP will give us valuable clues about how the agriculture sector can be developed in a sustainable manner. It will also give the findings that how the agricultural development in Uttar Pradesh will contribute to the national development as a whole.

1.7. Objectives of the Study

In the light of survey of literature the following are formulated as the objectives of the present study:-

1. To make a comparative analysis of agriculture sector in India with respect to its major states.
2. To evaluate the agricultural growth in India in comparison to other sectors of the economy.
3. To assess the level of agricultural development in Uttar Pradesh.
4. To examine regional disparity in agricultural growth in Uttar Pradesh.
5. To analyse the effects of different economic factors on the development of agriculture sector in Uttar Pradesh.

1.8. Hypotheses of the Study

The study aims to test the following hypotheses:

1. There is considerable inter-state variance in the growth of agriculture sector in India.
2. There is considerable inter-regional difference in the growth of agriculture sector in Uttar Pradesh.
3. Various factors have made a significant effect on the growth of agriculture sector in Uttar Pradesh.

1.9. Methodology

(a) Period of study: Since the economic reform was initiated in India in 1991, the much attention had been given to the development of secondary and tertiary sectors of the economy in order to put the Indian economy on the fast trajectory of growth and it has ignored their adverse effects on the agriculture sector in India as well as its major crop producing states. Therefore, an attempt has been made in the present study to analyse agricultural performance in India in general and Uttar Pradesh in particular after the reform period.

(b) Sources of data: The present study is heavily dependent on the secondary sources of data. These sources are primarily Govt. Ministries and departments at the centre and the state of Uttar Pradesh. In some other cases, reliable private sources have also been used. Among them, the main sources are, following are the lists of some sources of Agricultural data:-

6. NSSO, Ministry of Planning, New Delhi
8. Centre for Monitoring Indian Economy (CMIE) – Bombay

(c) Analytical Tools:
To arrive at relevant inferences a number of statistical and econometric techniques have been adopted. Some of them are followings:

1. Cobb–Douglas production function: To examine the allocation efficiency of resources in the cultivation of agricultural commodities, the Cobb – Douglas production function has been used. The adaption of this function has also assisted
in the estimation of elasticity of production of different factor inputs. The algebraic form of the function used in the analysis is as follows:

\[ Y = ax_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} \ldots \ldots \ldots \ldots x_n^{b_n} \]

In the log form it becomes,

\[ \log Y = \log a + b_1 \log x_1 + b_2 \log x_2 \ldots \ldots \ldots \ldots b_n \log x_n, \quad \text{where} \]

\( Y \) = dependent variable (output of agricultural commodities)
\( X_i \) = various inputs/factors affecting the output (Independent variables)
\( b_1, b_2 \ldots b_n \) are the elasticities of production with respect to input \( x_1, x_2 \ldots x_n \) respectively.

To ascertain the reliability of these least square estimates of the production function, the t-test of significance is needed. The value of ‘t’ is obtained by

\[ t = \frac{b_{xy}}{\text{S.E. of } b_{xy}} \]

Where, \( \text{S.E. of } b = \frac{\sqrt{(x-x_e)}^2}{\sqrt{(n-2)\sum y^2}} \)

2. **Index for Agricultural Efficiency (IAE):** It has been evolved by the following formula

\[ \text{AE}_r = \frac{P_r}{P} \]

Where, \( \text{AE}_r \) = Index for agricultural efficiency of the state

\( P_r = \) Per hectare production of agricultural commodity in the state

\( P = \) Per hectare production of agricultural commodity in India.

3. **Compound Annual Growth Rate (CAGR):**

The percentage annual compound growth rate in a variable has been calculated by first regressing the natural logarithm of the variable on time as follows:

\[ \ln Y_t = B_1 + B_2t + u_t \]

Where \( Y_t \) is value of the variable in \( t^{th} \) year whose annual compound growth rate is to be estimated. Further ‘t’ is year & number 1, 2, 3 etc were used for consecutive year.

And then the following formulae have been used for getting Annual compound growth rate (\( r \)) in percentage term.

\[ r = \left[ \text{antiLn}(\beta_2) - 1 \right] \times 100 \]

Where, \( r = \) Annual compound growth rate (%)
1.10. Limitations

As the study is entirely based on both time series and cross-sectional secondary sources of data obtained from different published sources, the authentic sources have been chosen without any personal bias. However, the limitations inherent in the secondary data are to be recognized. Wherever the study uses annual time series data, the lesser number of observations acts as a limiting factor. However, theoretical base or economic reasoning were supplied in such cases. Lack of strictly comparable data on some variable due to methodological changes between two years was also a major limitation of the study.

1.11. Plan of the study

Taking into consideration the importance of agriculture in Uttar Pradesh, the present work has been planned in the following sequence:-

The whole thesis is divided into seven chapters. The first chapter is ‘Introductory’ which states the relevance and need of the study in the context of Uttar Pradesh, and outlines the objectives, hypotheses to be tested, database used, and methodology adopted in the study. Second chapter makes an in-depth study of review of literature. Third chapter analyses the agricultural development in India vis-à-vis its major states. Trends in agricultural development in Uttar Pradesh has been analysed in Chapter four. Fifth chapter is concerned with analysis of various factors affecting the agricultural development in Uttar Pradesh. The last chapter i.e., chapter seven presents the summary of findings along with concluding remarks and suggestions for taking policy measures.

References:


