SUSTAINABLE GROWTH OF AGRICULTURE SECTOR IN RAJASTHAN

The Theme

Sustainable growth or sustainability of agriculture sector has been of interest of a number of research workers, particularly economists. Indian agriculture has, however, been considered sustainable before chemicalisation of agriculture and farmers produced organize food. The agriculture system was based on integration of soil and related ecological systems. According to Conway (1985) an agricultural system that can overcome a stress, defined as a discontinuity in the situation to which it is subject, can be referred to as sustainable. In context of Rajasthan failure of rains can be cited as an example. The FAO (1989) referred to sustainable agriculture as successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of environment and conserving natural resources and this was related to soil as an important resource base by Parikh and Ghosh (1991). Jodha (1991) defined sustainability as "the ability of the system to maintain a certain well defined level of performance over time, and if required to enhance the same through linkages with other systems without damaging the ecological integrity of the systems."

It is well known that agriculture is a dynamic system and all production processes work within the ecosystem or an agroclimatic zone, and its links with the ecosystem generally determines the optimum level of output. It has been observed that agroclimatic or ecological factors play a vital role in determining both correct policy options and levels of productivity as goals.

Broadly, Rajasthan is divided into arid and semi-arid regions, which are further demarcated into smaller agroclimatic zones. In these regions there are limitations on productivity, some show higher and other give low levels of productivity.

Therefore, for different agroclimatic regions an appropriate strategy would be needed for attaining desired productivity levels, or in other words, sustainability.

Sustainability in agriculture production provides food security and this has been defined by FAO (1983) as "All people at all time having both physical and economic access to the basic food they need". World Bank in 1986 further elaborated as "Access by all people at all times to enough food for an active healthy life. Its essential elements are the availability of food and ability to acquire it".

Swaminathan (1996) included a few more elements to enlarge the meaning of food security as "Livelihood security at the level of each household and all members within and involves insuring both physical and economic access to balanced diet, safe drinking water, environmental sanitation, primary education and basic health care".

"Food" is defined as food grains, fruits, vegetables, meat, fish and eggs. Along with 'Food Security', 'Nutritional Security' has also been taken into consideration by many researchers.

Recently, a report has come out on the 'State of Food Insecurity in India', prepared by the World Food Programme and M.S. Swaminathan Research Foundation (December, 2008). In this report, food insecurity index for Rural India (2004-06) has been given. For Rajasthan the index value of 0.50 is considered more food insecure. Kerala with 0.128-0.352 is least insecure. On this scale Rajasthan is more food insecure which is a matter of concern for all. The food security index is based on several parameters like food availability, access to nutrition and sanitation. This is different from the definition of 'Food Insecurity' that is linked with food availability.

This study addresses the issue of agricultural sustainability, which broadly includes food security to ward off food insecurity, particularly in the context of Rajasthan which is ecologically a fragile, dry land state with many problems facing its development. In fact there is a very thin line between 'environment' and 'development'. Therefore, it is important that for sustainable development and restoration of ecological balance, all policies of the agriculture sector must be critically examined from the view of their ecological long term impact. Many such policies run contrary to the 'development' goals and affect ecosystems due to unsustainable interventions.

Population growth and sustainable economic development are closely related as population is an indicator of human resources as well as of biotic pressure on natural resources and infrastructure. From a demographic perspective, Rajasthan is one of the most critical states in India. The state recorded the highest growth rate of +32.97 per cent in 1981 (over the previous decade) against an all-India growth rate of +25.00 per cent during the same period. In the past 100 years (1901 to 2001), states population has increased from 1.03 crore to 5.64 crore. It has been estimated that if the current trend in population growth continues, Rajasthan's population would reach nearly seven crores in 2011 and 8.2 crores in 2021. This could however, be less if the total fertility rate of 2.1 is achieved by 2011. Well thought out policies would be required to develop quality human resources to assist in sustainable development of the state.

The Thar Desert of western Rajasthan is the most densely populated of the World's hot deserts, with a density of over 75 persons per sq. km, compared to an average of 3 to 5 per sq. km in other deserts. In addition, the livestock population is also far in excess of the desert rangeland's carrying capacity, about 10 times the carrying capacity of 0.43 heads per ha. Therefore, there is a heavy biotic pressure on natural resources like land, water and vegetation in the area.

The biotic pressure of humans and livestock has been further increased by developmental activities like industrialization, mining, oil exploration, urbanization, irrigated agriculture, etc. Their impact on ecology has not been properly understood and quantified as 'development' goes on.

State Profile

Rajasthan was formed in 1949 after the integration of 22 princely states. No data-base of that time is available to measure the level of development in agriculture, animal husbandry, industry and infrastructure nor any estimates of sectoral income are available for these princely states till they were finally merged in the Indian Union in 1949. In general, productivity in agriculture was low, power generation from all sources was very poor, almost 90 per cent of villages had no road connectivity and level of literacy was dismally low. The region was extremely backward, both socially and economically. In short, on the eve of its formation, Rajasthan faced the following situation:

1) Very poor infrastructural facilities like roads, power, communication, transport, etc.
2) Neglected health and education systems.
3) An exploitative tenurial system.
4) Almost no industries.
5) Lack of marketing, price support and storage facilities for farm produce.
6) Poor banking facilities.
7) There was no policy to develop economy of the region.
8) No research and extension system for development in any sector of the economy.

Rajasthan is now the largest State of Indian Union after the division of some bigger states in smaller ones and spreads over 34.3 million hectare of land. It stretches to two of India's major physiographic divisions, namely the Great Plains (Indian Desert) and Central High lands. The Aravalli range of hills,

running from south-west to north-east, extending right up to Delhi, covers about 550 kilometers in Rajasthan and divides the state diagonally into two parts, the western arid region and the eastern semi-arid region. The area east of the Aravalli falls in the northern part of the Central Highlands. It is also a major water divide (watershed line) between catchment streams flowing into Arabian sea and Bay of Bengal, respectively. It has a steep but discontinuous front of the Thar Plains in the west and a relatively gentle slope to the alluvial basins in the north and the east. The area to the east of Aravalli hills is well drained by several integrated drainage systems, while the area to the west has only one drainage system of Luni river, in the south-eastern part of the desert. The central part of Aravalli, consists of an important basin of interior drainage, is gifted with the Sambhar salt Lake. The area is full of sand hills and a typical landscape with several low depressions.

Physiographically the state is divided into four broad regions:

1. Desert in dry western regions,
2. Aravalli hills region,
3. Eastern plains region, and
4. South-eastern plateau region.

The rivers of Rajasthan are rainfed, except the Chambal, and the quantity of water flowing in these rivers entirely depends on the quantum of rains received during the monsoon. The entire state is divided into 14 rainfed river valley catchments, with the Chambal catchment having maximum run-off followed by Mahi, Banas and Luni rivers.

The state has 10.4 per cent of the geographical area of the country with 5.5 per cent of the population (56.5 million), however, it has only one per cent of the India's total water resources, with the drawing potential of only 1.16 per cent.

The average rainfall of the state is 580 mm. The coefficient of variation in rainfall is very high as the rain is less than 100 mm (1 mm to 100 mm) in Jaisalmer district. As one moves from south–west to north- east, the rainfall goes on decreasing. It is maximum on the Aravalli near Mt. Abu where it exceeds 1000mm.

In Banswara, Chittaurgarh, Jhalawar, Baran and Kota the rainfall varies between 901mm to 1000mm. The highest Potential-Evapo transpiration (PET) of 2063.2mm has been reported at Jaisalmer in the west and 1745.2 mm in the east at Jaipur. The rainfall is the only source of water in the state, which is received from south-west monsoon which usually sets by mid-June and withdraws by September-end. On an average, the number of rainy days in a year is about 29. The rainfall is not only low but erratic in nature with long dry spells, which affects plant growth adversely. In general, wind velocity of 1 to 19 km per hour for majority of days is experienced in the state. The maximum temperature ranges between 45^{o}C to 49^{o}C during May-June in western region, while the night temperature ranges between 23^{o}C to 26^{o}C. Variations of as much as 22^{o}C in maximum and minimum temperatures occur in many parts of the state. The average relative humidity (RH) is 60 to 66 per cent, being a low of 50 per cent in the west to about 70 per cent in the east of Rajasthan.

The soils of Rajasthan are complex and highly variable, reflecting a variety of different parent material and physiographic land features. The soils in western region are light and coarse textured whereas the soils in eastern parts are heavy and clayey in texture. The soils of the state have been categorized into five specific orders, viz. Aridisols, Alfisols, Entisols, Inceptisols and Vertisols. All the soils have been identified into 22 soil series for particular characteristic and problems. Due to scarcity of surface water in the State, it depends on ground water resources to a great extent. The ground water development/ exploitation is very high in the eastern as compared to the western region. The annual ground

water recharge is relatively less in the western part of the state, largely owing to very low and erratic nature of the rainfall, absence of surface water sources and high evapotranspiration. The depth of water varies widely through out the state and varies between 10m to 25m and 20m to 80m in eastern region to western region, respectively. It has been estimated that over 80 per cent of the State has come under water level depletion zone during the period 1984 to 2002. Ground water resources computed as on 1.1.2001 reveal that out of 237 blocks in the state, only 49 blocks come under 'Safe' category, 21 blocks under semi-critical, 80 under critical and 86 under 'over exploited' category (One block of Churu district is entirely saline).

According to Rajasthan Forest statistics (2003) the recorded forest area of the state is 32,488sq.km. (9.40% of the total area of the State). This area has been classified into Reserved, Protected and Un-classified forest, which constitute 36.51, 54.33 and 9.16 per cent of the forest cover respectively. Contrary to this, as per Forest Survey of India (2001), only 16,367 sq. km. (4.78% of the total geographical area of the state) is estimated under actual forest cover. The ownership of the forest is mainly with the state government. The per capita availability of forest land is only 0.05 ha as against 0.08 ha in India. It has been estimated that for each Indian, the forest need is 0.47 ha for his basic requirements. The potential areas of expansion of forest cover are cultivable wastelands covering 4.73 million ha and part of fallow land and land other than current fallows, covering 4.14 million hectare (Joshi, 2007). The forests of the state can be categorized as under, which are mostly in edapho-climatic stage of succession:

1) Tropical Thorn forests: Ajmer, Jaipur, Dausa, Jodhpur, Jalore, Pali, Churu, Bikaner, Barmer and Jaisalmer.
2) Dry Teak Forests: Baran, Banswara, Chittaurgarh, Dungarpur, Jhalawar and Udaipur districts.

3) Dry Tropical Anogeissus Pendula Forests: Ajmer, Udaipur, Rajsamand, Chittaurgarh, Bundi, Sawai-Madhopur, Karauli, Dhaulpur, Kota, Baran, Alwar, Jaipur and Pali districts.

4) Tropical Dry Deciduous Mixed Forests: Bundi, Chittaurgarh, Kota, Sawai-Madhopur, Sirohi and Udaipur districts.

5) Sub-tropical Evergreen Forests: Sirohi district (Mt. Abu).

Agro-climate Zones of Rajasthan

For developing any sustainable plan for agriculture and allied subjects, it is essential that agro-climate conditions of an area is known. This will ensure scientific planning based on available natural resources on which improved production technology can be imposed. Earlier, Planning Commission (1988) delineated the whole country into 15-broad agroclimatic zones. Rajasthan covered four of them. These were further refined into 10 as under:

I. Arid Western Plains - Barmer, parts of Jodhpur.
II. Irrigated North Western Plains – Ganganagar, Hanumangarh.
III. Hyper Arid partially Irrigated Western Plains- Bikaner, Jaisalmer, parts of Churu.
IV. Transitional Plains of Inland Drainage - Nagaur, Sikar, Jhunjhunu, parts of Churu.
V. Transitional Plains of Luni Basin - Jalore, Pali, parts of Sirohi, Jodhpur.
VI. Semi- arid Eastern Plains - Jaipur, Ajmer, Dausa, Tonk.
VII. Flood - Prone Eastern Plains- Alwar, Bharatpur, Dhaulpur, Karauli, parts of Sawai Madhopur.
VIII. Sub- Humid Southern Plains & Aravali Hills- Bhilwara, Rajsamand, parts of Udaipur, parts of Chittaurgarh, parts of Sirohi.
IX. Humid Southern Plains- Dungarpur, Banswara, parts of Udaipur, parts of Chittaurgarh.
X. Humid Southern Eastern Plains- Kota, Baran, Bundi, Jhalawar, parts of Sawai Madhopur.

Since socio-economic factors directly influence agricultural production, the Planning Commission in its Report of the Committee on '25 years Perspective Plan for the Development of Rainfed Areas (1997), divided the country into four agro-economic zones based on certain agro-economic characteristics like level of land productivity, incidence of rural poverty, etc. These are as under:

Zone-1: Areas with relatively high productivity, with either high levels of irrigation or highly assured rainfall and low incidence of poverty: No area of Rajasthan comes in the zone.

Zone-2: Areas with relatively low productivity, high rainfall, low level of irrigation and high incidence of poverty-Chittaurgarh and Jhalawar.

Zone-3: Areas with low productivity, low rainfall and high incidence of poverty-Ajmer, Alwar, Banswara, Bharatpur, Bhilwara, Bundi, Dhaulpur, Dungarpur, SriGanganagar, Jaipur, Jhalawar, Kota, Pali, Sawai Madhopur, Sirohi, Tonk and Udaipur.

Zone- 4: The desert districts

Potential development areas for each of the zone and districts have been identified which could be integrated with district development plans, particularly related to agriculture sector.

REVIEW OF SOME EARLIER WORK

Acharya, *et al* (1990) studied the agro-climatic zones of the state and suggested a development strategy for Rajasthan. They combined the strategy and actions based on the reports of zonal planning teams for zone 6 (Trans Gangetic Plains), zone 8(Central Plateau & Hill Region), zone 9(Western Plateau & Hill Region) and zone 14(Western Dry Region) identified by the Planning Commission in 1988. Based on a critical appraisal of on– going agriculture development programmes and agro-climatic characters of each district, they suggested an integrated approach as under:-

1. An extended scale of watershed development and minor irrigation programmes.
2. New programmes of aerial seeding of grasses/ bushes, cattle improvement, live-stock based industries, silage and hay making.
3. Fodder security and banking.
4. Emphasis on arid crops, arid fruits.
5. Conservation of rain water in arid areas.
6. Greater research efforts on farming systems and irrigation water management.

Acharya (2004), while discussing opportunities, challenges and policy formulation for agricultural development in Rajasthan made several points on the agricultural scenario of Rajasthan and suggested an agriculture policy frame work which would lead to stability and sustainability which would benefit the farmer and ultimately the state economy.

The PHD Chamber of Commerce and Industry, Rajasthan organized a round table conference on Rapid Economic Development of Rajasthan in 2004. It identified sectors having high growth prospects and agro-processing was one of them. The issues of concern raised were:-

1. Increasing yield of agricultural produce.
2. Expansion of irrigation facilities.
3. Increasing investment in agri-and rural infrastructure.
4. Continued lack of infrastructure for food processing industries.
5. Developing non-traditional plants like medicinal plants, herbs, oilseeds and pulses.
6. Increasing the efficiency of the food supply chain.
7. Multiple taxes and levies (to be reduced/ abolished).
8. Lack of awareness of farmers.

While delivering the Keynote Address at a Seminar on Water Resources at Social Policy Research Institute, Jaipur , Vyas (2004) emphasized on various aspects of water and water requirements for sustainable development in Rajasthan. He mentioned the following major policy issues to be tackled at the state level:-

I. **Issues related to the augmentation of water supply-** Conservation of rain water and avoiding wastage and an economizing the use of water.
II. **Issues related to the governance of water use from various sources like-** Inter-state rivers, surface water, ground water.
III. **Issues related to equity -** equity in availability and requirements of water at regional level, inequality in rural- urban distribution, inequality in distribution among different sections.
IV. **Issues related to pricing and privatization-** consider water as a social good, pricing of water for other uses, role of market, scope for public-private partnership.

A Study on a Historical Perspective on Development of Rajsathan's Economy was made by Social Policy Research Institute (2004). The report has made a number of suggestions and recommendations on agriculture and water resources development to achieve the goal of sustainability in agriculture and allied sectors. The report concluded that for the development of rainfed areas of the state, the state Government must have a vision to address the following issues:

1. Integrated development of rainfed areas on a watershed approach where inter-sectoral linkages are explicit and organic in nature.
2. Management of natural resources for sustainability.
3. Ensure people's participation in agricultural development programmes, from planning to monitoring.
4. Give priority to investment in rainfed areas for production.

5. Encourage agro- industries in production sites.
6. Encourage water- saving devices for an economic use of water, particularly for fruit and vegetable production.
7. Drought management must be an on –going process built in the state extension system for preparedness and management of situations.
8. Under the state policy, priority should be on development of agriculture and allied activities, with adequate funding.
9. State Land Use and Water Use Policies should be formulated.
10. All watershed development programmes should be under one command and be implemented with a single broad guidelines.
11. Rules and regulations should be framed for continuing and equitable supply of water.
12. There should be provisions of penalty on units responsible for polluting ground water.
13. Crop and live-stock insurance schemes should cover all sub-sectors.
14. Revamp agriculture credit policy for farmer friendly approach.

Mruthyunjaya, *et al* (2004) studied the impact of selected technologies refined under National Agriculture Technology Project (NATP) and concluded that return to investment in dissemination of available technologies are enormous and the responsibility lies with the public extension system which is very weak. Rajasthan showed large advantages in cotton production, inter-cropping of maize and aonla and house-hold food and nutritional security with minor millets, Khatkar, et al. (2004) suggested that investments on technology up gradation for value addition to pearl millet are quite attractive and beneficial. This should be encouraged in the state through the revamping of the extension agencies.

Mathur (2005) advocated Agro-climatic Regional Planning (ACRP) approach in formulation of long-term strategy for sustainable development of agriculture in the state. This will help in maximizing the use of land and water resources of each specific region/area, involving people, technology and management institutions for enhancing the out-put and income through optimizing the natural and other production resources. Under this, plans and programmes of different line departments are integrated with convergence of resources of various schemes.

Rapeseed & Mustard are important oilseed crops of Rajasthan and prices greatly affect their production scenario. Pandey, et al. (2005) compared oilseed production (rapeseed & mustard) in Rajasathan and Punjab. Their results of econometric analysis have indicated that the expected prices and price risk are important determinants of oilseed production. Further, the potential efficiency gains from insurance schemes have been substantial over self-insurance in oilseed production. Jain, *et al* (2005) also studied risks in output growth of oilseeds in Rajasthan. They concluded that a policy for better implementation of support price system, development of consistently performing varieties and further enchancement of irrigation facilities will go a long way to ensure stability in Rajasthan's agriculture and asked farmers to take up oil seed crop insurance and suggested as under for this:-

Crop		**District**
- Sesamum	:	Pali, Jodhpur, Nagaur
- Groundnut	:	Jaipur, Chittaurgarh, S.Madhopur, Bikaner
- Soyabean	:	Kota, Jhalawar
- Rapeseed & Mustard	:	Sri Ganganagar, Bharatpur, Alwar, Sawai-Madhopur, Tonk
- Taramira	:	Nagaur, Bikaner, Pali.

According to Chand, *et al* (2005) to minimize risks and get more income on a sustainable basis, diversified agriculture, organic farming, cultivation of different crops/cultivars, horticulture, agro-forestry, silvi-pasture, dairy and commercial goat and sheep rearing have been suggested for the arid region of Rajasthan.

According to Kalamkar (2005), to face the uncertainties owing to agricultural commodity price fluctuations, contract farming and forward markets are the most convenient and safer options, which will come to the rescue of not only the small and marginal farmers in terms of guaranteed income and low capital investment but also the nation as a whole, making it globally competitive and provide insurance against price volatility. For managing risks of drought in arid and semi-arid regions of India, Badatya (2005) has out lined the role of credit and suggested that appropriate strategies have to be evolved in terms of appropriate crop planning, thrust on irrigation, watershed development, encouragement to rural non-farm sector for employment creation, etc., depending on resource endowment.

The Rajasthan State Development Report (SDR) of the Planning Commission (2006) critically analyzed plans, programmes and achievements in all major sectors of development. The Report concluded that great thrust needed to be given to the State Land Use Policy and State Water Policy in order to achieve the long-term goals of sustainable agricultural development in the state. It also emphasized on agro-climatic zonal planning approach. The Report has also made a number of suggestions on improving the cropping systems, development of horticulture, organic farming, animal husbandry-breeding, feeding and management, agro-processing, water and watershed development, etc.

Vyas and Singh (2006) also advocated crop insurance in India and made some suggestions for improvement in the scheme. Rajasthan was found far below Maharashtra, Andhra Pradesh, Madhya Pradesh and Gujarat for share in crops

insured and share in area under insured. The economic viability of Henna (*Lawsonia sp.)* cultivation in the semi-arid region of Rajasthan has been studied by Chand and Jangid (2007). The study suggests that based on factors like net present value, internal rate of return (IRR), benefit–cost ratio (B:C), henna cultivation was found to be a financially viable proposition. However, it is more sensitive to change in price than cost. Chand and Sharma (2007) specifically studied the growth performance of vegetable crops in different agro-climatic zones of Rajasthan. The performance of zone III B (Alwar, Bharatpur, Dholpur, Sawai Madhopur, Karauli) was better than other zones in vegetable production. Considering wider variability in area than production and productivity of vegetable crops, the study has suggested that efforts should be made to stabilize the area to improve value productivity in the state.

According to Vyas (2007) village common lands are dwindling seriously upsetting the ecological balance, disturbing the symbiotic relationship between agriculture and animal husbandry, and adversely impacting the economy of the poor households of the state. He further added that there was an absence of proper land and water use policy for the state. After reviewing various aspects of sustainable development, he concluded that Rajasthan's agriculture is at cross, roads and required bold and imaginative initiatives in the state policy, investment strategy and institutional support to resolve its predicaments. On similar issues Rathore (2007) suggested that a balance needed to be maintained in the sectoral land use, water use and biomass use to avoid short and long term negative ecological consequences. The author made some important points on this issue as under:-

1. The existing land use classification needs to be changed by adding few more categories namely, mining and quarrying lands, urban lands, industrial lands, water bodies etc.
2. Western Rajasthan needs specific attention in terms of land use planning.

3. Besides initiating a new agricultural policy, the need is for creating more jobs in non-farm sector, i.e. diversification of occupation.
4. Check sub-division of land by reviewing the state land tenancy policy and land consolidation.
5. Improve quality of forests and their area.
6. All policies must address the surface and ground water pollution by various agencies/bodies.
7. Credit and subsidy policies for the energy sector need a review in the context of water and environmental consequences.
8. Check ground water demand and initiate community based ground water recharge.
9. Ground water and surface water pollution by any agency in any manner should be treated as a criminal act.

Joshi (2007) has done a comprehensive review on the extent of land use and degradation in Rajasthan taking into consideration the present land use patterns in the districts for various purposes. According to him there is no clear-cut land use policy and wrong policy choices have aggravated the problem of land degradation. He is very critical of intensive irrigation in command area of *Indira Gandhi Nahar* which after 10 years has created a number of problems. He suggested that the land which was suitable for intensive irrigation should be used for pasture land development and animal husbandry should be promoted in the desert for sustainability and not agriculture (crop production). He has also suggested adequate changes in land use classification system.

Relevant issues and approaches with regard to agricultural development of Rajasthan have been studied by Sagar (2007). The studies upto 2001 revealed that the agriculture sector (including animal husbandry) showed a significant decline in growth rate between 1961-91 and 1991-2002. High growth rate in both ***Kharif***

and ***Rabi*** crop production was recorded in 1991-92 to 2001-02 over 1980-81, wheat, ***Kharif*** oilseeds, food grains, vegetables, condiments and spices recording significant growth rates. ***Rabi*** oilseeds and cotton recorded negative growth rates during the same periods. As far as crop area is concerned, total area under crops showed positive growth rate during 1991-92 to 2001-02. In the same period, high growth rates in the area was recorded under rice, wheat and oilseeds (very low compared to 1980-81 to 1991-92 period). Negative area growth rates were noticed in food grains, ***Kharif*** cereals, ***Rabi*** oilseeds. In case of growth in crop productivity all the crops had positive growth rates in 1981-91, 1991-2001 and 1981 to 2001. However, all the crops showed lower growth rates during *1981-2001 as compared to 1981-91 periods*. The growth rates in net irrigated area, gross irrigated area, net cropped area and gross cropped area showed higher growth rates in 1991-2001 as compared to 1980-91. In case of fertilizer consumption it was just reverse, but still it was quite high. The study, however, revealed that growth in productivity was nowhere commensurate with the growth in the fertilizer consumption.

After examining all related issues including capital formation in agriculture, the author concluded as under:-

1. More emphasis is given on price factors and less on non-price factors.
2. Input subsidies result in/ encourage inefficiency in resource use.
3. Promote live-stock based farming system in bajra area, with green folder, dry fodder, coarse grain feed for live-stock and poultry.
4. Promote coarse grain as health food after processing.
5. Allocation of crop area be in such a fashion that the long-term sustainability of the crop system is ensured in every agro-climatic environment.

The live-stock sector is vital for the state economy. In fact it is believed that growth in live-stock sector helps in the growth in agriculture sector. This is very true for the large western part of the state. Ray (2007) examined some issues related to sustainable live-stock development in Rajasthan. According to him there is no integrated state policy for sustainable development of the live-stock sector. The State runs development programmes only but no one knows how sustainable they are? He suggests that state must follow a pragmatic approach and seek reforms of its live-stock policy. Further, no policy exists to regenerate a high stock of pasture lands and to improve its carrying capacity and to utilize it in a sustainable manner for live-stock development. In the breeding policy, he suggested Selective Breeding as the hybridization programme failed in the state. The breeding policy should be integrated with development of village pastures by the village community within an institutional framework in collaboration with the state, if necessary. As far as marketing is concerned, there is a system in place for marketing of big animals and animal products. There is a very weak policy for small ruminants. There is a need to evolve new marketing policy to generate sustainable livelihood for sheep rearers. For this development of Common Facility Centres (CFC) was suggested by him, which should be formed by sheep rearers, within an institutional frame work, to integrate all activities of sheep husbandry. The author also suggested a live-stock services and delivery system. It will help in providing services of improved quality in a cost-effective manner. It has also been suggested that commercialization of these services could be considered that have no externalities and leave those that have externalities to the public sector.

On the performance of a National Insurance Scheme of Agriculture, Raju and Chand (2008) made some suggestions, which are important to impact sustainability to a farmer to face risks. These should be looked into by the Government as agriculture is not only drought prone but also highly risk prone.

A study done in IGNP Phase II in Jaisalmer district, has revealed the advantages of shelterbelt plantation and has recommended that the Government should encourage shelterbelt plantation on the boundaries of agricultural fields to increase the farm income (Gajja, *et al* 2008).

Birthal, *et al* (2002) and Das and Khunt (2008) studied research priorities in live-stock sector in India and Gujarat, respectively. Such studies for Rajasthan are very much needed in view of great importance of this sector in Rajasthan economy and sustainable life particularly in the western region of the state. The suggestions given for Gujarat seem to be true for Rajasthan also. The priorities identified are: (i) improving the efficiency of live-stock production, (ii) integrate live-stock into sustainable systems, (iii) take into account rural development, equity, food security, social development and gender issues, and (iv) use financial resources in a well planned manner. Kumar, *et al* (2008) mentioned that productivity growth in agriculture is essential for the development of the sector, and so is sustainability. This helps in evolving policies towards food security, arresting deceleration in total factor productivity, identifying factors for enhancing yield of major commodities, focusing on empowering small farmers and women, identifying areas for environment protection and strengthening the state agricultural research system.

Keeping in view these, the present study will provide a framework to develop policies for long-term planning and sustainability in agriculture and animal husbandry sectors. For this secondary data on various aspects will be critically examined in the light of earlier experiences.

NATURAL RESOURCES BASE

Land Resources of Rajasthan

The total geographical area of the state is 34266151 ha (34.26 million ha). Forest covers 2.66 million ha or 7.76 per cent area. Over 17 million ha area, of the total geographical area is under plough (50%). Nearly 61 per cent of the total area of the state is desert- the *Thar* in the western region. The 550 km long Aravalli range intersects the state diagonally from southwest to north-east, extending up to Delhi. Broadly the western region is arid and eastern region is semi- arid.

Rajasthan has five specific soil orders as Aridisols of arid region, Alfisols, in large areas of the state, Entisols, Inceptisols in foot hills of Aravali and Vertisols of southern Rajasthan. Western districts like Bikaner, parts of Nagaur, Jodhpur, Jaisalmer and Barmer have, by and large, sandy soil where due to high porosity, water generally percolates below the sub-soil. Sandy soil is generally devoid of nitrogen and carbonic salts resulting in production of only low value crops. On the other hand, Jaipur Alwar, Bharatpur, Tonk, Kota, Dhaulpur etc. have alluvial soil which is fertile. Dungarpur, Banswara, Udaipur and Chittorgarh have black-loamy soil. It is capable of producing good crops only with good management. The desertic soils are found in Jalore, Jodhpur, Naguar, Barmer, Churu and Jhunjhunu and have low fertility.

It is of utmost importance that the land resource is managed properly to its capability for sustainable development. The changes in the land use(or mis-use) scenario will provide an important input for better planning of sustainable agricultural development in the state.

Land use

Planned development in India was started from the beginning of the First Five Year Plan (1951-56). Since then eleven plans have been completed. The basic idea of Five Year Plan is to make development taking into account aims and objectives, resources both physical and financial and execute the work in coordinated manner for the benefit for all. The geographical area of the state is 342 lakh hectare and all categories of land use have to be planned and executed within those ones only as this entity is fixed. Progress in development /achievements are categorized presently as per the nine-fold classification followed all over the country. Its merit and demerits are not discussed here. Detailed trends in land-use in Rajasthan from I Plan to X Plan (2002-07) are given in Annexure- I. Some major categories, relevant to this study are discussed below in Table-1.

Table - 1
Plan-wise Trends in Land Use in Rajasthan
(In Percentage to Geographical Area)

Plan	Forest	Permanent Pasture & others	Cultivable Wasteland	Fallow Lands	Not sown Area	Gross Cropped Area	Double Cropped Area
I (1951-56)	3.82	—	—	16.84	31.14	33.20	2.06
II (1956-61)	3.12	4.46	20.7	16.10	37.1	40.30	3.17
III (1961-66)	2.85	5.18	19.18	13.25	40.73	43.75	3.02
IV (1969-74)	4.14	5.30	17.61	12.01	43.49	47.81	4.32
V (1974-79)	5.55	5.32	19.00	12.80	43.70	49.20	5.52
VI (1980-85)	6.24	5.38	17.90	12.00	45.60	52.90	7.34
VII (1985-90)	6.65	5.31	17.00	14.69	43.41	50.19	6.78
VIII (1992-97)	7.14	5.13	15.20	11.10	48.90	58.60	9.72
IX (1997-02)	7.51	5.02	14.60	13.30	47.20	60.10	13.00
X (2002-07) **up to 2006**	7.78	5.00	13.60	16.28	45.02	56.76	11.74

Source: 1. 50 – Years of Agricultural Development in Rajasthan, Directorate of Agriculture, Government of Rajasthan, Jaipur

2. 50 – Years of Agricultural Statistics of Rajasthan 1956-57 to 2005-06, Directorate of Economics & Statistics, Rajasthan, Jaipur.

3. Statistical Abstract 2009, Rajasthan, Directorate of Economics & Statistics, Rajasthan, Jaipur.

Forest

The forest area in the State as per record increased from 3.82 per cent (I Plan) to 7.78 per cent by 2006 suggesting a 3.96 per cent or nearly 4 per cent increase during the period. However, it may be mentioned that after reorganization of

Indian states in 1956, some areas of Mt. Abu were included in Rajasthan, which may have increased total forest area in the State. The other important aspect of forest is its denseness. According to the Forest Survey of India (2001) Rajasthan had only 1.85 per cent dense cover, 6322 sq.km. out of a total 16,368 sq. km and the rest 10,045 sq km was an open forest (2.93%). According to Joshi (2007) the per capita available forest is only 0.05 ha in Rajasthan as compared to 0.08 ha all India level, where as the requirement of forest resource per person is 0.47 ha. Thus, other categories of land will have to be brought under forest cover like wastelands of various types. The ideal forest cover is considered as 33 per cent of the geographical area. In case of Rajasthan, where more than 60 per cent area is desert, this can not be attained. Therefore, we have to increase the green cover, wherever possible, to save our land resources.

A perusal of region-wise data shows that although small but there is definitely some stability in forest cover as shown below (Table-2).

Table - 2
Region-wise Forest Area in Rajasthan

(%)

Region	1971-1993	1999-2001	2003-2004	% Area of the State District covered
Jaipur	3.60	7.00	7.17	10.66 Ajmer, Jaipur, Dausa, Sikar, Jhunjhunu
Bharatpur	8.80	14.40	14.90	7.57 Alwar, Bharatpur, Dhopur, S. Madhopur, Karauli
Ganganagar	0.20	2.50	2.58	18.94 Bikaner, Churu, Ganganagar, Hanumangarh
Jodhpur	1.10	2.40	2.49	39.36 Jodhpur, Jaisalmer, Jalore, Barmer, Nagaur, Pali, Sirohi.
Kota	10.17	19.80	19.97	0.20 Kota, Baran, Bundi, Jhalawar, Tonk
Udaipur	15.80	24.60	24.87	6.87 Banswara, Dungarpur, Udaipur
Bhilwara	4.50	11.30	11.56	7.40 Bhilwara, Chittorgarh, Rajsaman
State	4.10	7.60	7.76	100

Sourece : Rathore (2007) modified

This shows that Udaipur region with 6.87 per cent area of the State has a 24.87 per cent forest cover and Jodhpur region having the highest area at 39.36 per cent has only 2.49 per cent which is the lowest, forest cover, followed by Ganganagar. These two regions cover 11 western districts of desert area. One may remember that Indira Gandhi Canal provides irrigation water in the districts of Bikaner, Ganganagar, Hanumangarh and Jaisalmer. Together these four districts got irrigation water on 7,062,00 ha land. The National standard of 33 per cent land area to be under forest is less than 8 per cent in Rajsthan and for the desert area of the state it is less than 3 per cent. It is necessary, however, to maximize the green cover with all available resources of land and water for sustainable development and environment.

Bagchi (2006) classified land area into five geographical areas as (i) North Arid: Ganganagar and Hanumangarh (6.02 % area), (ii) Southern Plains: Banswara, Dungarpur, Pali, Sirohi, Udaipur, Rajsamand, Bhilwara and Chittorgarh (19.39 % area), (iii) Eastern Plains: Kota, Bundi, Ajmer, Baran, Tonk, Jaipur, Dausa, Alwar, Bhartpur, Sawai Madhopur, Dholpur, Karauli (21.61 % area), (iv) Southern Plateau: Jhalawar (1.85 % area) and (v) West Arid: Barmer, Bikaner, Jodhpur, Churu, Jaisalmer, Jalore, Sikar, Jhunjhunu and Nagaur (51.13 % area). From 1956-59 to 1998-2001, the forest area in Rajasthan increased from 3.66 per cent to 7.46 per cent. The region-wise increases are given as under:

Table-3
Region-wise Percentage of Forest Area in Rajasthan

Region	1956-59	1997-2000	Percent Area of State
I North Arid	--	3.20	6.02
II Southern Plains	10.55	16.26	19.39
III Eastern Plains	5.66	13.67	21.61
IV Southern Plains	6.22	18.99	1.85 (only Jhalawar)
V West Arid	0.16	1.58	51.13
Rajasthan	3.66	7.46	

Rathore (2007) attributed the increase in forest area in Rajasthan to (i) forest lands got properly demarcated; (ii) state and national level awareness about environmental issues, along with Supreme Court directions to check deforestation etc., and (iii) external and internal funding for afforestation and the State's special efforts to improve conditions of forest lands. He, however, did not comment on the quality of forest land.

Permanent Pastures and Other Grazing land

Pastures are crucial for animal husbandry, particularly for Rajasthan. The animal population is almost the same as human population, thus there is 1:1 ratio between humans and animals. The economy of the western region largely depends on animal husbandry, particularly on milk and wool production. A perusal of Table- 1 reveals that almost nothing has been done to develop or sustain pastures and grasslands in the state. Between the First Plan and the Tenth Plan area under grasslands varied from 4.44 per cent to 5.00 per cent. From VI plan (1980-85) there has been a gradual decline in area under this important land use suggesting mis-use by diverting to some other use. Annexure –II provides district-wise areas under pasture and grazing land. The lowest percentage of land under this category is in the highly irrigated districts of Rajasthan, viz Ganganagar (0.02%) and Hanumangarh (0.41%) (2003-04). Since 1996-97 there has been a decline or stagnation in the area under pasture and grazing lands in the districts of Ajmer, Jaipur, Dausa, Sikar, Jhunjhunu, Alwar, Dhaulpur, Sawai Madhopur, Karauli, Bikaner, Churu, Ganganagar, Hanumangarh, Jodhpur, Jaisalmer, Barmer, Nagaur, Sirohi, Jhalawar, Tonk, Banswara, Dungarpur, Udaipur, Bhilwara and Rajsamand. Some increases were recorded in Bharatpur, Jalore, Pali, Kota, Baran, Bundi and Chittorgarh. The region-wise figures also show that it was the lowest in the North Arid Region

(Ganganagar and Hanumangarh) and the highest in the Southern Plateau (Jhalawar) and the Southern Plains (southern districts) (Bagchi, 2006).

From an Agro-climatic point of view the following scenario emerges with regard to pasture and grazing land availability (Ann. III) which provides information for each district under a particular zone.

Table no. 4 below shows agro climatic zone wise picture.

Table - 4

Agroclimatic zone-wise Pasture Land Area in Rajasthan

Agroclimatic zone	Geographical Area of Zone (%)	Percent area under Pasture	Area in ha
I a- Arid Western Plains	13.64	12.62	325200
I b- Irrigated North Western Plains	6.05	0.61	4203
I c- Hyper Arid Partially Irrigated Western Plains	22.16	7.16	194043
IIa- Transitional Plains of Inland Drainage	10.62	18.87	130673
II b- Transitinal Plains of Luni Basin	8.64	23.7	293864
III a- Semi- arid Eastern Plains	8.52	30.2	226337
III b- Flood Prone Eastern Plains	7.97	21.89	106716
IV a- Sub Humid Southern Plains & Aravalli hills	9.67	32.3	329440
IV b- Humid Southern Plains	4.95	25.96	223265
V Humid South Eastern Plains	7.78	20.70	126196

Source: Directorate of Agriculture, Rajasthan, Jaipur (Vital Agriculture Statistics, 2005-06)

It is quite apparent that agro climatic zone I (a) to I (b) have less area under pastures whereas they have high animal population. Biomass production per

unit of land and quality of the pasture determines animal productivity. These issues remain unresolved.

There has been a gradual decline in the area under permanent pastures and grazing lands in Rajasthan. In 1997-98 it was 5.02 per cent of the total geographical area which declined every year and was 4.94 per cent in 2000-01 and remained almost the same thereafter (upto 2005-06). This shows that there is hardly any attention towards this valuable national resource so vital for growth of animal husbandry sector.

It is quite clear that pastures and grazing lands have been declining in the state as has also been reported by Raj (2007). He analysed the trends in availability of grazing and fodder collection, stocking of animals, composition shifts in animals, carrying capacity of cattle units and area available per cattle unit, on broad zonal basis of arid, semi-arid, sub-humid and humid zones. Accordingly the pattern of land utilization that emerged during the last three decades or so has serious implications for (1) Sustenance of live-stock development in view of the shrinking carrying capacity of land and (2) live-stock bio-diversity vis- a-vis its compositional change. These issues will be considered in shaping a State Live Stock Policy which will also include Pasture and Grassland development.

Culturable Land

Under culturable land use pattern the following categories of lands are classified:

1. Permanent pastures and grazing lands
2. Culturable Waste lands
3. Fallow lands: (a) Fallow lands other than current fallow (b) Current fallows
4. Net Area sown

Periodic changes in culturable land are shown in Table-5. From 1956-57 to 2005-06, there have been significant changes in the culturable land use in Rajsathan:

Table - 5

Land Use Pattern in Culturable lands in Rajasthan

(Area in lakh ha)

Category of Land Use	1956-57	1970-71	1980-81	1990-91	1995-96	2000-01	2005-06
i) Permanent Pastures	13.8	18.07	18.34	19.12	17.45	17.07	
ii) Culturable Waste lands	73.26	61.12	64.16	55.67	51.04	49.08	
iii) Fallow lands other than current Fallow	33.11	23.26	20.89	19.67	19.72	24.44	
iv) Current Fallows	22.48	14.43	20.85	18.14	20.35	24.15	
Net Area Sown	124.25	151.79	152.67	163.77	165.75	158.65	
Total Culturable land	266.9	268.67	276.91	275.97	274.32	273.39	
Percentage of Geographical Area	77.89	78.41	80.81	80.54	80.06	79.79	
Percent change		0.52	2.4	-0.27	-0.48	-0.27	

Source: 50–Years of Agricultural Statistics of Rajasthan 1956-57 to 2005-06, Directorate of Economics & Statistics, Rajasthan, Jaipur.

From total land availability for bio-mass production (excluding forest lands), the culturable land area increased from 267 lakh ha to 273 lakh in a period of about fifty years, that is about 6 lakh ha.

Table - 6

Agroclimatic Zone	2001-01	2003-04
I	41.88	43.64
II	71.53	71.96
III	69.35	75.35
IV	48.87	42.44
V	53.85	58.25
VI	55.79	56.70
VII	27.65	28.06
VIII	39.43	40.11
IX	46.45	47.04
Total (State)	**48.92**	**50.04**

Source: Research Highlights, 1997, Directorate of Research, Rajasthan Agriculture University, Bikaner (Modified)

The lowest area under cultivation is in Zone VII (Sub-humid Southern Plains and the Aravallis) and Zone I (Arid Western Plains), where Udaipur district has less than 17 per cent land under cultivation (Zone VII) and Jaisalmer less than 15 per cent (Zone I). Udaipur is a hilly tract and Jaisalmer is an arid region. The availability of irrigation in Ganganagar and Hanumangarh (Zone II) has converted these districts as highly cultivated.

Permanent pastures and the net area sown showed an increase where as culturable wasteland and fallow lands showed a decrease. At first this shows a positive trend, but an examination of the periodic data does not show any positive signs. The permanent pasture covered 18.34 lakh ha in 1980-81, 19.12 lakh ha in 1990-91 and since 1995-96 till 2005-06 are stagnating around 17 lakh ha. There has been an increase in the animal population during these periods reducing the availability of pasture lands per animal. The decrease in culturable wastelands from 73.26 lakh ha in 1956-57 to 45.90 lakh ha in 2005-06 is significant (over 27 lakh ha). This area has been converted into the net sown area, increasing it by 44 lakh ha. This is a disturbing trend. Irrespective of the quality or land capability, the marginal areas of wastelands have been put under plough to increase the sown area. The total culturable land has shown a negative trend from 1990-91 to 2005-06.

The distribution of land under cultivation in nine agro-climatic zones is given in Annexure V.

Water Resources and Development

Water is one critical determinant for the existence of life. Water has always been considered a free commodity given to us but the situation has now completely changed to the point where, particularly in more arid and semi-arid areas of Rajasthan, water scarcity has become the single greatest threat to food and

fodder security and the sustainability of natural ecosystems. Rajasthan has barely 1.16 per cent of the water resources of the country and an 11 per cent share in the total geographical land. Rajasthan is a rainfed state and the rain is the main source of water. The rivers of the state are non-perennial except Chambal and Mahi and only a few of them join any defined drainage system and get lost in the sands or natural drains into inland poundages like the Sambhar salt lake. Total water resources from all the sources of surface, underground and interstate transfer account for 45.09 BCM, and the utilization is 35.76 BCM, which is 81 percent of the total available water (Rathore, 2007). The available water and its utilization, as per its use has been projected by the Department of Irrigation, Government of Rajasthan in Vision 2045 and an Expert Committee on Integrated Development and Management of Water Resource in Rajasthan, June, 2005 (as reported by Rathore, 2007). These have been summarized in Tables 7, 8 , and 9. There are obvious variations in projections about the availability or utilization of water resources in Rajasthan. The important issues that come out are (i) irrigation accounts for nearly 90 per cent use of total available water for different purposes, (b) underground water utilization is over 100 per cent and (c) there is a scope to increase irrigation efficiency for net gains. Another important aspect which is evident that, source wise almost 50 per cent demand is met by the surface and 50 per cent by the underground water (it comes to 52% and 48%, respectively). A region/district-wise analysis (Rathore, 2007) shows that in 1960 the area irrigated, by source, was 58.5 per cent from tube wells and wells, 25.2 per cent from canals and 15.2 per cent from tanks in Rajasthan which has now changed to 72.72 per cent by wells and tube wells, 25.08 per cent by canal (no change) and 1.14 per cent from tanks in 2003-04. This shows over exploitation of groundwater. Districts with 90 to 100 per cent net sown area by wells and tube wells are in the regions of Jaipur (99.35%), Bharatpur (94.86%) and Jodhpur (94.64%). The Ganganagar region has 87.08 per cent canal irrigation and Udaipur

region around 40 per cent from canal and wells each. Bhilwara region is mainly irrigated by wells (87.47%) and Kota both by wells (64.14%) and canals (31.52%).

Table - 7
Water Resources: Availability and Utilization in Rajasthan

(in BCM)

Source	Availability	Utilization
Surface[1]	33.94 (2000)	23.95 (71%)
Surface[2]	22.17 (2015)	12.97
	23.38 (2045)	16.87

Source: -1. Rathore (2007), based on Expect Committee Report, 2005
2. Vision 2045, Irrigation Dept., Govt. of Rajasthan, 2000.

Table – 8
Demand and Supply of water in Rajasthan

(in BCM)

	2005	2015	2045
Demand			
Surface Water	20.9	27.7	40.0
Ground Water	19.2	17.4	17.1
Total	40.1	45.1	57.1
Supply			
Surface water	18.8	22.1	33.0
Ground Water	13.6	14.0	14.7
Total	**32.4**	**36.1**	**47.7**
Shortage	**7.7**	**9.0**	**9.4**

Source: - Rathore (2007), based on Expect Committee Report, 2005

Table - 9
Purpose-wise Demand of Water in Rajasthan

(in BCM)

S. N.	Purpose[1]	2005	2015	2045
1.	Domestic	2.6	3.2	4.7
2.	Live stock	0.9	1.1	1.3
3.	Irrigation	35.9 (89.5%)	40.0 (88.7%)	49.1 (86.0%)
4.	Others	0.7	0.8	2.0
	Total	**40.1**	**45.1**	**57.1**
			2015	**2045**
a. Non-Agricultural Demand[2]			5.05	8.07
b. Irrigated Area (Lakh ha)			50.59	57.00
On- farm Irrigation Efficiency (%)			44.20	70.00
Off-farm Irrigation Efficiency (%)			61.20	72.00
Domestic Water Supply Distribution Efficiency			64.00	70.00

Source: - 1. Rathore (2007), based on Expert Committee Report, 2005
2. Vision 2045, Irrigation Dept. Govt. of Rajasthan, 2000

Exploitation of groundwater resources helped in providing drinking water to the increasing population, in the absence of PHED supply and in expanding the irrigated area to increase the production of food grains and vegetables. This has, on the other hand created a serious problem of groundwater over-exploitation. A number of studies have been done on this aspect and both the Central Groundwater Board and the State Groundwater Boards have also warned about the serious consequences of the uncontrolled mining of groundwater. There are four categories of groundwater status in the state, namely, 'Safe' (withdrawal is less than recharge), 'Semi-Critical', 'Critical and 'Over-exploited' (dark zone) where over exploited blocks were 59.3 per cent out of total 236 Blocks. If one adds 'Critical' Blocks of 21.2 per cent the total comes to 80.5 per cent and 'Safe'

only 13.6 per cent which were 74.7 per cent in 1984. This situation is alarming and a big hindrance in a sustainable development of the state.

A study was conducted by the Social Policy Research Institute (SPRI) in 2004 on the status of groundwater in districts of Rajasthan (based on 2001 status). It was revealed that there were a large number of districts, with major populations, where groundwater balance varied between upto – 29 mcm and over – 400 mcm. These are listed as under: -

Table - 10

Negative Groundwater Balance in Rajasthan: -

S. N.		
1.	Over 400 mcm	Jalore (100%)
2.	200 to <400 mcm	Jaipur (84.6%), Jodhpur (55.6%), Nagaur (63.6%)
3.	100 to <200 mcm	Alwar (92.9%), Jhunjhunu (87.5%)
4.	50 to <100 mcm	Chittaurgarh (92.9%)
5.	Over – 30 mcm	Ajmer (75%)
6.	Upto – 29 mcm	Barmer (62.5%), Bhilwara (72.7%), Dausa (100%), Dholpur (50%), Sikar (87.5%), Udaipur (72.7%)

Source: Study on Inter - Regional Economic Inequalities in Rajasthan, 2005, Social Policy Research Institute, Jaipur (www.planning commission.nic.in)

The data also provide interesting information that in 1984, 100 per cent blocks were in 'Safe' category, but large percentages of them came down as 'Over-Exploited' in 2004 like Dholpur 50%, Bikaner 40%, Churu 20%, Jaisalmer 66.7%, Sirohi 40%, Kota 80%, Baran 28.6%, Bundi 50 per cent, Jhalawar 33.3%, Tonk 16.7%, Banswara 0% but 75% of them Semi-Critical and Critical categories. In the

case of Barmer 62.5% blocks were 'Safe' and 12.5% over-exploited in 1984. In 2004 the situation has just reversed.

Irrigation and Agriculture

The irrigated area in Rajasthan increased from about 12 per cent in the first Five Year Plan period (1951-52 to 1955-56) to nearly 36 per cent of the sown area by the Tenth Five Year Plan (2002-03 to 2005-06). This greatly helped in increasing agricultural production, particularly food grains along with encouraging farmers to adopt high yielding varieties of food grains and providing adequate nutrients for higher production per unit area. These are given in table below: -

Table - 11

Impact of Irrigation Water on Agriculture : Plan-Wise

S. N.	Plan-Period	Percent Irrigated area to Sown area	Average Production of food grains (Lakh tonnes)	Average area under HYV (Lakh ha)	Average fertilizer consumption (Nutrients kg/ha)
1.	1951-52 to 1955-56	11.35	48.98	-	-
2.	1956-57 to 1960-61	12.17	46.40	-	-
3.	1961-62 to 1965-66	12.40	47.57	-	0.48
	1966-67 to 1968-69 (Annual Plans)	13.52	48.34	0.98	1.53
4.	1969-70 to 1973-74	14.84	63.51	7.54	3.48
5.	1974-75 to 1978-79	18.02	70.36	12.76	5.69
6.	1980-81 to 1984-85	19.99	79.94	24.65	9.45
7.	1985-86 to 1989-90	23.19	106.56	25.52	15.29
	1990-91 to 1991-92 (Annual Plans)	-	-	-	-
8.	1992-93 to 1996-97	29.62	105.56	33.41	29.29
9.	1997-98 to 2001-02	33.08	123.39	37.98	37.34
10.	2002-03 to 2005-06	35.86	121.31	36.36	48.52

Source: 1. 50 – Years of Agricultural Development in Rajasthan, Directorate of Agriculture, Government of Rajasthan, Jaipur
2. 50 – Years of Agricultural Statistics of Rajasthan 1956-57 to 2005-06, Directorate of Economics & Statistics, Rajasthan, Jaipur.

Irrigation creation not only resulted in an increased irrigated net sown area but also increased irrigation intensity, with some fluctuation owing to availability of water for irrigation purposes from canals as well good rainfalls. This is given in the Table -12 below: -

Table - 12

Irrigated Area and Irrigation Intensity (1960-61 to 2005-06)

Year	% Irrigated Area to Net Sown Area	% Irrigation Intensity
1960-61	13.36	119.01
1970-71	14.07	114.84
1980-81	19.54	125.68
1991-92	28.04	121.21
1997-98	31.75	123.15
1998-99	33.33	122.45
2000-01	31.00	109.31
2001-02	32.32	124.00
2002-03	40.45	121.00
2003-04	30.11	122.00
2004-05	35.53	-
2005-06	37.38	124.22

Source: 1. 50 – Years of Agricultural Development in Rajasthan, Directorate of Agriculture, Government of Rajasthan, Jaipur
2. Vital Agricultural Statistics 2005-06, Directorate of Agriculture, Government of Rajasthan, Jaipur

Watershed Development

Rajasthan is a major rainfed state with not only a low but a rainfall which is uncertain and erratic in distribution. As a consequence the productivity levels of rainfed crops are low. In fact the total bio-mass production is low causing concern for both human and animal population, which are almost equal. It is well known that since 1967-68 there have been about 30 drought years of varying degrees. It is also said that out of every 5 years there are 3 draught years. In the year 2002-03, only 52.12 lakh tonnes of food grains could be produced, against 139.83 lakh tonnes in 2001-02, as the entire state faced a severe drought. Droughts of such magnitude were also faced in 1968-69, 1969-70, 1972-73, 1974-75, 1980-81, 1981-82, 1982-83, 1985-86, 1986-87, 1987-88, 1989-90, 1991-92, 1993-94, 1995-96, 1999-2000 and 2000-01. Rajasthan has arid to semi-arid regions which encounter serious problems of erosion and degradation of natural resources. Loss of vegetative cover followed by soil degradation through various forms of erosion has resulted into such lands which are 'thirsty' in terms of water as well as 'hungry' in terms of soil nutrient for plant growth. The most scientific approach to the development of rainfed areas has to based on the 'watershed' concept.

'Watershed' is defined as a geographical area of overland (surface) drainage that makes the water of a particular stream flow at a chosen point. The watershed or the drainage basin is thus the natural unit of the run-off and reflects as a drainage area whose run-off flows past a certain defined point. It is an entity from which water flows into a stream, lake or any other point of drainage. Watershed, thus, is a geo-hydrological unit, which drains or contributes a run-off to a common out let. It has a ridge, a drainage line and an outlet. In fact, watershed can also have non-distinguishable drainage lines like in low rainfall and desert areas. In such an eco-system, the watershed means an index

catchment, but supports large underground aquifers or a group of small aquifers beneath the earth surface.

The broad *objectives* of a watershed development could be as under: -

(1) To protect, conserve and manage natural resources like, land, water and vegetation resulting in a restoration of the ecological balance.
(2) To improve productivity of bio-mass and thereby increasing employment and income opportunities for the people.
(3) To involve people for community participation and maintenance of assets created in a watershed area.
(4) To provide social equity in a community.
(5) To develop animal husbandry and other activities as per the need of the people.

Thus, for maximizing the advantages, all developmental activities should be under taken in an integrated and comprehensive way on a watershed basis. The main principles of watershed management are:

(a) Land utilization as per the land capability.
(b) In situ conservation of each drop of rain.
(c) Collection of excess or run-off water in storage ponds for future use.
(d) Controlling soil erosion with various measures and recharge of groundwater.
(e) Enhancing productivity of per unit area, per unit time and per unit of water.
(f) Introduction of inter-cropping and sequence cropping.
(g) Following the farming system approach to enhance productivity through crop-livestock-tree-labour complex over a period of time to generate larger income opportunities.

(h) Providing cushioning effect under aberrant weather situations which lead to loss in production system, training of extension officials for contingency crop planning, etc.

(i) Providing infrastructural facilities like storage, transportation, marketing, agro-processing units, training, etc.

The Rajasthan Government has accepted the watershed concept for the development of rainfed areas. Out of 342 lakh ha of geographical area of the state, 240 lakh ha has been identified for watershed development treatment based on areas where assured irrigation is less than 30 per cent (canal irrigation). So far about 44 lakh ha has been treated under various watershed development schemes like NWDPRA, DPAP, DDP, IWDP, EAPs and others, at a cost of Rs. 2352.32 crore (upto December, 2008). Details are given in Annexure VI.

It is envisaged that 4 to 5 lakh ha would be treated per year under various watershed development programmes. At this pace it would take 49 to 39 years (or say 50 to 40 years) to treat all rainfed areas of the state requiring watershed development. To provide an overall sustainability in agriculture sector to such vast areas, should we wait for so long and then what are the other ways? How can we accelerate the pace of development so as to reach the goal 20 to 25 years? What are the policy matters and what would be the financial implications? All these will have to be examined for sustainable agriculture.

The progress in watershed development is slow because 1 lakh ha only per year have been treated. The slow pace of development could be attributed to the following reasons: -

1. It took a long time to adopt the watershed concept in soil conservation programmes.

2. There was a shortage of trained personnel in undertaking integrated watershed development projects.
3. There was hardly any coordination between various agencies and integrated plans were implemented as sectoral programmes only.
4. Soil conservation programmes in the state are being executed since 1957, which were implemented on individual field basis by the Agriculture Department. However, in the mid-eighties the concept of integrated watershed was adopted. In the Nineties, emphasis was given on a participatory integrated approach. There have been changes in the guidelines given by the Ministry of Agriculture for NWDPRA and the Ministry of Rural Development for DPAP, DDP, IWDP. These changes created confusion at field level and the progress was hampered.
5. Lack of follow-up and maintenance of assets resulted in a slow progress as owing to some local reasons, community participation could not be ensured.

For effective implementation of watershed programme under various centrally sponsored schemes, the Department of Watershed Development and Soil Conservation was created in the state in 1990-91. Recently, new guidelines have been issued for all watershed works. In pursuance of the 73rd Constitutional Amendment, all watershed development works under various schemes are being implemented through the Gram Panchayats the. However, as per the new guidelines the PIAs may include relevant line departments, autonomous organizations under the State/Central Governments, Government Institutes/Research Bodies, panchayats and voluntary organizations. The Zila Parishad is the District Nodal Agency which is the overall in charge of all the watershed development works being implemented under the various schemes. It also deals with all the accounts and technical aspects of watershed works.

The watershed development of the state has been recognized at the National level. From 1993-94 to 2005-06, seven watersheds were given best watershed award at the national level by the National Productivity Council, Rajiv Gandhi Parti Bhumi Mitra Award and Indira Gandhi Priyadarshini Award. Several other watersheds have been given second best or Certificate of Merit award. Some evaluation studies done by an ngo on the watershed works during early nineties revealed many short comings which included a poor people's participation, little change in land use and cropping pattern, poor vegetative cover, lack of extension support, lack of coordinated approach, etc. With time it seems that things have improved. An impact evaluation made by Taylor Nelson Sofres (2002) of 462 watersheds of the state revealed that: -

i) On an average, net area sown and gross cropped area increased by 12 per cent.
ii) Irrigated area increased from 27 to 40 ha per watershed as a result of development of water resources.
iii) Depth of water table increased by 6 per cent.
iv) Yield of crops increased from 10 per cent to over 70 per cent.

In order to strengthen and enlarge the implementation of watershed development fresh policy decisions will have to be taken by the Government.

Sustainability in Crop Production

To achieve stability and sustainability in the agriculture sector, the most important factor is a sustainable production of crops, particularly food crops. This has been the practice since long as food crops like wheat, rice, jowar, maize, bajra, ragi and pulses formed those food grains which were essential to feed the population. Commercial and industrial crops were not considered essentials. As time changed, the needs for the people expanded use of, technology yielded

results. Commercialization of agriculture was also considered important to enhance farmers' income and improve his purchasing power. Today food production is not just a production of food grains but 'Food' includes food grains, milk, fruits, meat, poultry, fish, etc. in a basket. Along with meeting the food requirements, it is also important to consider nutritional requirements under 'Food & Nutritional' security for the people. For Rajasthan 'Production Sheet' scenario is as under in Table – 13 :

Table – 13

Production Scenario of Rajasthan (Lakh tonnes)

Year	**Food grains**	**Cereals**	**Pulses**	**Rainfall (mm)**	**Cropping Intensity (GAS/NAS*100)**	**Irrigation Intensity**	**Remarks Rain fall (+) (-) %**
1960-61	45.41	33.39	12.02	450.9	106.87	119.01	-21.60
1970-71	88.41	70.64	17.77	617.5	110.21	114.84	+7.37
1980-81	64.96	53.26	11.69	423.9	113.64	125.68	-26.29
1990-91	109.34	92.15	17.18	72.73	118.34	119.17	+26.46
2000-01	100.40	93.08	7.31	574.3	121.21	125.01	-0.14
2005-06	108.23	99.23	8.99	565.3	128.88	124.22	-1.70

Cropping Intensity (GAS/NAS)*100
Irrigation Intensity (GAI/NAI)*100

Source: 1. Vital Agricultural Statistics various issues, Directorate of Agriculture, Government of Rajasthan, Jaipur
2. 50 – Years of Agricultural Statistics of Rajasthan 1956-57 to 2005-06, Directorate of Economics & Statistics, Rajasthan, Jaipur.

The normal rain fall of the state is 575.10 mm and the total water requirement of major Kharif crops like Bajra, Maize and Jowar is around 450 to 550 mm. It is not only the total amount of rainfall but its distribution which is also important for normal crop production. The above Table shows that even a high irrigation intensity of 125.68 per cent in 1980-81 could not help in food grains production when rainfall was a - 26.29 per cent deviation from normal. The figure from 1960-

61 to 2005-06 depict the non-sustainable nature of food grains production in Rajasthan. It may be mentioned that in 1980-81 food grains production declined from 88.41 lakh tonnes in 1970-71 to 64-96 lakh tonnes in which wheat contributed 23.93 lakh tonnes. A higher rainfall (+26.46%) in 1990-91 resulted in a higher cropping intensity by 5 per cent only. Between 1967-68 and 2002-03, there were 19 years of severe drought when 20 or more districts faced drought conditions.

The area, production and yield of 12 major crops of Rajasthan from 1961-62 to 2005-06 are given in Annexure-VII.

Growth Rates in Area, Production and Yield of Crops

There have been wide fluctuations in the compound growth rates in area, production and yield of crops since 1960-61. These are given in Table 14 for periods 1960-61 to 1969-70 (pre green revolution), 1970-71 to 1979-80 (early post Green revolution), 1980-81 to 1989-90 (pre-Reform), 1990-2000 (Reform Period) and 1999-2000 to 2007-08 (Post Reform).

Table – 14

Compound Growth Rate for area, production and yield

(Per cent)

Crop	1960-61 to 1969-70			1970-71 to 1979-80			1980-81 to 1989-90			1990-91 to 1999-00			1999-00 to 2007-08		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Jowar	-0.52	-0.15	-1.12	-3.66	-6.46	-1.27	-0.45	-2.17	0.77	-5.03	-6.48	-1.53	0.68	12.09	11.81
Bajra	0.64	-1.46	-2.26	-3.14	-11.26	-12.09	-0.25	2.35	3.25	-1.66	-0.82	0.86	2.53	11.62	8.92
Maize	2.07	2.58	-3.9	0.62	-1.92	-1.56	0.02	0.99	2.35	-0.245	0.46	-0.7	1.17	4.96	2.82
Sesamum	1.82	-4.21	-1.84	-5.16	-7.86	-1	-3.33	-1.05	1.26	-11.39	-20.69	-10.65	5.83	24.23	14.24
Groundnut	9.13	3.76	-2.91	3.42	-1.55	-3.78	3.88	9.3	6.01	2.74	5.02	2.21	3.60	12.00	7.64
Soyabean	-		-	-	-		38.94	44.19	1.21	16.21	19.3	2.63	4.04	4.04	4.88
Guar	-		-	5.06	6.54	16.01	-1.73	-5.79	0.7	1.57	-3.83	-5.36	2.36	17.63	2.06
Wheat	-0.01	1.27	0.91	4.16	5.49	0.78	-1.15	2.58	4.26	4.92	6.46	1.46	-1.04	1.33	2.57
Barley	-0.97	0.14	3.46	-1.24	-1.42	-0.43	-6.99	-3.49	4.12	-1.85	0.2	2.1	-1.38	4.41	2.94
Gram	-3.55	-3.18	0.78	1.21	3.41	1.87	-5.14	-5.67	1.25	3.13	8.57	2.7	4.55	4.39	3.29
Rape and mustered seed	-5.43	-3.74	1.14	-0.78	-2.02	-3.19	12.95	16.82	4.99	2.75	3.83	1.05	10.77	15.34	4.31

Amongst all the major crops, barley is the only crop which showed a negative growth rate in the area during all the periods. However in absolute terms, its production declined from 6.74 lakh tonnes to 4.58 lakh tonnes in 2005-06. Its productivity, however, showed improvement which was 10-11 q/ha earlier and increased to less than 20q/ha by 1998-99. After that it was above 20q/ha. This helped in increased production but the total production was less than it was in 1961-62. From water consumption point of view this needs attention. Barley will use much less water than wheat and has a ready market which can be stream-lined for greater profitability. Wheat also showed a negative growth rate in the area between 1999-2000 and 2007-08 but had positive growth rate in production and yield. The yield varied between 27 and 30 q/ha between 2001-02 and 2006-07.

Jowar is a dry land crop and it is unfortunate that its growth rates have declined between 1960-61 and 2007-08. In area terms, from 12.31 lakh ha in 1961-62 it came down to 6.25 lakh ha in 2007-08. A similar picture emerges for production and yield. Bajra, which is a major rainfed crop of Rajasthan occupying 40 lakh ha to 50 lakh ha area, depending on the behavior of the monsoon, had a negative growth rate in area sown between 1970-71 and 1999-2000, but showed a positive growth between 1999-2000 and 2007-08 with a high positive growth rates for production and yield also during this period. The data, however, show wide variations in production and yield from 1960-61 to 2007-08 and this factor needs to be addressed for future stability of production of this major crop of the state.

It is interesting to note that during 1999-2000 to 2007-08, all the major crops not only showed positive growth rates in production and yield but the levels of growth also were quite high. Sesamum showed 24.23 per cent growth rate in production and 14.24 per cent in yield, the highest amongst all the crops. This was followed by guar, rapeseed & mustard, jowar and bajra in production and jowar, bajra, groundnut and soyabeen in productivity.

Trends inProductivity of Crops: Agroclimatic Zonal Studies

Sustainability in crop production depends very much on productivity of crops along with the area sown for total production level. The total factor productivity of various crops of Rajasthan has been studied by some scholars and these have already been discussed earlier. The productivity per unit area for each crop is given in Annexure – VIII (graphs) for agroclimatic zone in which it is grown. These are given for major crops such as:

- Kharif Crops: Bajra, Jowar, Maize, Sesamum, Soybean, Kharif Pulses.
- Rabi Crops : Wheat, Barley, Gram. Rabi Pulses, Mustard.

Productivity reflects the extent to which inputs have been used and production technology adopted along with great influence of weather for kharif crops.

As is well known, productivity of crops in the state of Rajasthan varies greatly and largely depends on the behavior of the rainfall. Therefore, there are two types of productivity variations, one between unirrigated and irrigated crops and the other between research and demonstration and irrigated yield levels. The differences in irrigated and unirrigated yield levels for some crops are given as under: -

Table- 15

Productivity of Irrigated and Unirrigated Crops in Rajasthan

(In kg/ha)

Crop	Irrigated					Unirrigated				
	1973-74	1983-84	1993-94	2003-04	2005-06	1973-74	1983-84	1993-94	2003-04	2005-06
Maize	305	836	1302	2158	1199	839	1399	895	1838	1023
Wheat	1261	1735	1795	2881	2826	620	934	968	1291	1006
Barley	1135	1549	1491	2262	2282	578	1129	891	1312	1701
Gram	729	718	773	1058	791	389	558	630	476	186
Rape seed & Mustard	545	839	764	1453	1325	148	753	714	922	647
Groundnut	1252	844	1030	1868	1841	578	918	568	1215	1087
Cotton (Lint)	225	242	272	349	326	26	90	205	443	298

Source: 50 – Years of Agricultural Statistics of Rajasthan 1956-57 to 2005-06, Directorate of Economics & Statistics, Rajasthan, Jaipur.

There variations are due to availability of water either through irrigation or rains, research efforts and dissemination of production technology through

the agricultural extension system. It is also evident that in case of gram, irrigation impact is neither marked nor consistent. This could be owing to gap in research.

Some research efforts of recent years are summarized to point out gaps in yield levels at demonstration and farmers levels for agroclimatic zone III (a).

Table- 16

Productivity of Crops under Demonstrations and at farmers' Fields

(q/ha)

Crop	Demonstration	Farmers practices
Moong	7.0	6.2
Guar	52.2	47.4
Til	4.5-5.8	3.6
Bajra	22.5-26.0	18.1
Cotton (Kapas)	24.6-28.5	25.1
Mustard	18-21.5	14.6-16.4
Gram	15.7	12.2
Wheat (Irrigated)	37.5-43.8	37.6
Barley (Irrigated)	35.5-49.5	36.3
Onions (Irrigated)	40.5-46.6	35.8

Source: Directorate of Agriculture Research, Durgapura, Jaipur.

This is only illustrative and similar gaps exist for all crops under different agroclimatic conditions. The major issue is how to bridge these gaps on a sustainable basis? Effective extension coordinated approach may be are the answer.

Bajra

Bajra is a major kharif food crop of the state and occupied over 23 per cent of the total cropped area in 2005-06.

During 1975-76 to 2005-06, Bajra productivity in Zone Ia (Bikaner, Barmer, Jaisalmer and Jodhpur) was most unstable and never crossed the 500 kg/ha level. In 1970-71, Jaisalmer recorded over 3500 kg/ha yield level which was based on the study of a small area only. A similar trend was also noticed in Zone-I (b) comprising of Ganganagar and Hanumangarh where the area under in Ganganagar was very small. In 1970-71, Ganganagar (which also included Hanumangarh) then recorded over 2000 kg yield per hectare of Bajra. After wards, there was a declining trend. In Zone II a (Nagaur, Churu, Sikar, Jhunjhunu), the yield varied between over 500kg (highest) in 1970-71 in Jhunjhunu to over 700 kg/ha in Nagaur in 1990-91. There has been a wide fluctuation in the zone. A similar trend was also noticed in Zone II-b (Jalore and Sirohi) with the highest productivity of 1000 kg/ha in 1970-71 for Jalore and less than 400kg for Sirohi for the same year. Bajra is also an important kharif crop of Zone III (a) (Jaipur, Tonk, Dausa, Ajmer). In the zone the highest yield of 1400 kg/ha was produced in Tonk in 1990-91 in a very small area. Otherwise instability in production was seen at all the places since 1960-61. A steady increasing trend in productivity levels of Bajra was seen in Zone III (b) of Alwar, Dhaulpur, Bharatpur, Sawai Madhopur and Karauli. The highest yield of over 1600 kg/ha was obtained in Dhaulpur which has also shown a steady, higher trend. In Zone V (Kota, Bundi, Baran, Jhalawar), in 1970-71, Jhalawar recorded over 5000 kg/ha yield level from a very small area but never attained over 500 kg/ha level in other years.

Jowar

Jowar was cultivated on 2.73 per cent of the total cropped area of the state in 2005-06. In Zone I (a) it is important in Jodhpur only where yield levels fluctuated with the highest of over 400 kg/ha in 1990-91. Since then it has never crossed even a 200 kg/ha level. After Jodhpur, Jaisalmer has a small area under

this crop. Barmer is similar to Jaisalmer in area and yield levels with periodic fluctuations. There is no point in encouraging this crop in this Zone except in Jodhpur and Bajra can replace the small area in other districts for both grain and fodder. In Zone II (a), it is grown in Nagaur only and other districts are not important. In 1990-91 the highest yield of 600 kg/ha was in Nagaur but thereafter it remained below the 400 kg/ha level. In other districts, yields up to 10 q/ha were obtained from very small areas. All the three districts of Zone II (b) cultivate Jowar with the largest area in Pali, followed by Jalore and Sirohi. Sirohi seem to be a promising area as compared to other districts. In Zone III (a) all the four districts of Ajmer, Dausa, Jaipur and Tonk grow Jowar with the largest area in Ajmer followed by Tonk and Jaipur. However, the yield levels never crossed 600 kg/ha in this zone and Ajmer remained below 100 kg level since 1995-96 to 2005-06. This needs examination. In other areas more emphasis should be given to soil and moisture conservation measures for increasing yield levels.

Bharatpur and Alwar in Zone III (b) grow Jowar to some extent. Yield levels, however, are better in Sawai Madhopur in a lesser area. In Dhaulpur and Karauli the crop is not important. It can be encouraged in Alwar, Bharatpur and Sawai Madhopur if soil and moisture conservation measures are taken and better varieties provided. It is grown in all the four districts of Zone IV (a) with more area in Bhilwara as compared to other districts.

Rajsamand is better suited for Jowar cultivation than Bhilwara and Udaipur and even Chittorgarh.

It is also grown in all the four districts of Zone V. All these districts have potential to step up the productivity levels with better water and input management and yield level of more than 12q/ha can be attained.

Maize

Maize is a major crop of Zone IV (a) comprising areas of Udaipur, Bhilwara, Chittorgarh and Rajsamand. The highest yield level of 18 q/ha was obtained in 1970-71 at Chittorgarh. In other districts, the yield levels were below 14 q/ha, with appreciable variations. A similar situation was in Zone IV (b) of Banswara and Dungarpur. In Zone V (Baran, Bundi, Jhalawar, Kota) the highest yield of about 22 q/ha was recorded in Baran and at Kota 21 q/ha. The trend for the Zone is, however, positive. In Zone III (b) maize is an important crop in Alwar district only, where an yield upto 20 q/ha was obtained in 2000-01. Thus also wide variations have been seen in different years. In Zone II (b) it is an important crop in Pali and Sirohi where the highest yields were obtained during 1990-91. However, the yield was up to 8q/ha.

Kharif Pulses

Kharif pulses (excluding Arhar) are grown in almost all the districts of Rajasthan but in a much lesser area in Alwar, Bharatpur, Karauli and Dhaulpur.

In Zone I a, there is a decreasing trend in productivity and wide fluctuations in productivity levels. There is a need to take special measures to provide sustainability to Kharif pulses production in this Zone. Zone I (b) of Hanumangarh and SriGanganagar seems to be a low productivity Zone with Ganganagar showing a productivity of 500 kg/ha only in 1990-91 and the rest of the years less than 400 kg/ha. Hanumangarh has even less than this level. The production, efforts are and need efforts for sustainability and increasing the levels of productivity with better input management and adoption of improved production technology. In Zone II (a), there is a near stagnation in yield levels of Kharif pulses showing a decreasing trend. The general level is less than 400 kg/ha. In Sikar 650 kg/ha was harvested in 1990-91 and above 500 kg in 1970-71 in Jhunjhunu. In this region also better input use and production technology can

improve yield levels. In Zone II (b) although the area under Kharif pulses is sizable, there is a declining trend in productivity. Since 1990-91 productivity level is declining in all the districts of this zone. This needs attention. In all other Zones either there is stagnation or a declining trend. For increasing and stabilizing production of Kharif pulses, in the interest of food security and nutritional security, all out efforts are required in almost all agroclimatic Zones of the State.

Sesamum

Til (Sesamum) is grown in all the areas of Rajasthan except in Jhunjhunu district. In Zone I (a), the trend in yield level is negative. The yield level it self is very low. Research efforts are required for a breakthrough in production of sesamum in this zone. Zone I (b) seems to be a promising area for sesamum. In Ganganagar a yield upto 10 q /ha was attained earlier which has drastically come down to less than 200 kg/ha between 1995-96 and 2005-06 periods. However, Hanumangarh has given a better performance as it has around are an 8 q/ha yield level. The productivity is showing an increasing trend.

In Zone II (a) Nagaur is an important sesamum growing district but the yield level is low and is showing a declining trend. All the three districts of Jalore, Pali and Sirohi of Zone II (b) have sizeable area under crop with Pali having the highest. In general, there is a declining trend in productivity. In 1990-91, all the three districts recorded the highest yield level which varied between 400 kg to above 500 kg/ha. Production technology needs to be improved to stabilize area and yield levels in this zone with use of high yielding disease resistant and input responsive varieties. It is an important crop in Zone III (a) for all the districts of Jaipur, Ajmer, Dausa and Tonk. In 1990-91, all of them recorded the highest yields, the highest in Tonk (450+kg/ha), Ajmer (425kg/ha), Jaipur (350+kg/ha) and Dausa (325kg/ha). There is an increasing trend in productivity but the level

is still low. Greater research efforts are needed to improve production technology in this area Zone III (b) is also important from the area coverage point for sesamum. The highest yield of about 800 kg/ha was recorded in 1990-91 at Sawai Madhopur. In the districts of Alwar, Bharatpur, Dhaulpur and Karauli, it fluctuated but was less than 500kg/ha. The trend is improving but wide fluctuations have been noticed. Good high yielding varieties, with improved production technology are needed for sustainability. Another important Zone is IV (a), comprising of Udaipur, Bhilwara, Chittorgarh and Rajsamand. Unfortunately, yield levels in this zone are low and the highest recorded in 1995-96 at Chittorgarh was (350kg+/ha). At Bhilwara and Rajsamand about 325 kg/ha was attained in 1990-91. The low levels of yield are a cause of concern for this important sesamum growing area and needs a production breakthrough. The same is true for Zone IV (b), comprising of Banswara and Dungarpur. In Zone V of Baran, Bundi, Jhalawar and Kota, the highest yield of 400+kg/ha was recorded at Kota in 1990-91 followed by less than 350 kg/ha in 1975-76 at Jhalawar. In 1990-91 Baran and in 2005-06 Bundi, the trend is improving but gradually. Again better production technology is the need of the hour.

Groundnut

It is grown in a large number of districts covering an area of 2 to 3 lakh ha. In Zone I (a), it is more important in Bikaner and does not cover much area in Barmer. There has been an increasing trend in yield and Bikaner recorded the highest at 20q/ha in 1990-91. Thereafter, it went down but again showed an improvement Jaisalmer and Jodhpur have given more than 15 q/ha yield levels. There is a great scope to improve yield levels, however, with better management of input use and irrigation water. In Zone I (b) groundnut is showing a better performance in Hanumangarh and there has been an increasing yield level between 1990-91 and 2005-06 with the highest yield of about 1600 kg/ha in 2005-

06. Ganganagar has shown ups and down with the highest level of over 1400 kg/ha obtained in 1990-91. Zone II (a) has shown a good performance in groundnut productivity with improving trends for all the four districts - Nagaur, Churu, Sikar and Jhunjhunu. The yield levels varied from 16 to 20 q/ha, with the highest in Sikar. With better water and crop management, yield levels can be improved.

In Zone II (b), the crop is important in Pali and Sirohi districts with a small area in Jalore. In Pali it has not shown a good result with wide fluctuations in productivity and the highest of 1000 kg/ha was attained in 1965-66. In recent times it is less than 800 kg/ha. In Sirohi, there has been an improving trend in yield levels since 1995-96. Its cultivation can be increased as a productivity level of nearly 1600 kg/ha has been obtained.

There is a sizeable area under groundnut cultivation in Zone III (a) comprising of Jaipur, Ajmer, Dausa and Tonk. The productivity levels have shown an increasing trend and the highest of over 18 q/ha were obtained in 2005-06. Ajmer has remained at a low level all through and varied between 200 kg/ha in 1965-66 and above 600 kg/ha in 1970-71. In Jaipur, Dausa and Tonk the area under it is bigger. Therefore, strategies to improve yield levels in Ajmer may be different then in other districts. The stability of groundnut production in this Zone is important as it covers 80,000 ha to 90,000 ha area out of over 2 lakh ha of the State. In Zone III (b), Sawai Madhopur has more area under it followed by Karauli. In other districts of this Zone, not much area is put under groundnut. In Sawai Madhopur, the yield level never exceeded 10 q/ha whereas in Bharatpur and Dhaulpur it was nearly 16 q/ha. Karauli attained 13 q/ha. The trend is positive and more efforts are needed to encourage groundnut cultivation in this Zone, with an improved production technology and water management.

Chittorgarh is a major groundnut growing district in Zone IV (a) followed by Bhilwara, Udaipur and Rajsamand. In Chittorgarh there is an increasing trend of yield levels and the highest of 14q/ha was obtained in 2005-06 period. Rajsamand and Bhilwara have shown similar yield levels of 11 q/ha whereas Udaipur has always been around 8 q/ha. This is a promising groundnut growing area and research is needed to provide specific varieties for this Zone with improved production technology for higher yield as well as high good quality oil. Jhalawar and Kota in Zone V is potential groundnut growing areas with 15q-16q/ha of present yield level. In other areas, yield levels are good and need exploitation with improved production technology.

Soybean

Soybean is a new crop for Rajasthan as it is grown only in a few districts of the State.

In Zone III (b), it is important only in Sawai Madhopur and is showing good results. The highest yield of about 1200 kg/ha was obtained here in 2005-06. In Zone IV (a), it is important in all the districts except Rajsamand. The productivity is 1200 kg/ha showing an increasing trend. All the districts achieved a high yield level of 11-12 q/ha in 1990-91. Thereafter, yield levels declined but improved again in 2005-06. In general, there is an increasing yield/ha trend and the potential to step up the yield levels along with oil content with improved water management and production technology exists. In Zone IV (b), Banswara is the only district which grows Soybean in a sizeable area. It obtained the highest yield of more than 11 q/ha in 1990-91. Thereafter, there was a decline with jump again in 2005-06 with an over 10 q/ha yield. In Dungarpur, the area is not much but the yield level of nearly 12q/ha was achieved in 2005-06. There is potential to expand cultivation of Soybean in this agroclimatic zone.

Zone V is the most important area growing Soybean in all the four districts. In fact, out of about 5.5 lakh ha, the four districts of this Zone viz. Jhalawar, Kota, Baran and Bundi cover about 4.3 lakh ha. There is an increasing trend in yield levels showing a good potential. The highest yield of 14 q/ha was achieved in Bundi in 1990-91 and 2005-06. Only Jhalawar had about 10q/ha yield level. This is also a high potential Zone for improving and stabilizing production at high level in the state.

Rice

Rice occupies over one lakh ha in Rajasthan out of which 50 per cent is in Udaipur, Banswara and Dungarpur districts, followed by Ganganagar, Hanumangarh and Kota region with the highest in Bundi district. In Ganganagar and Hanumangarh it is 100 per cent irrigated (Surface irrigation). In Banswara, Dungarpur and Udaipur, it is rainfed. There are, however, vast yield differences under irrigated and rainfed conditions.

In Zone I (b), there has been a declining trend in yield levels of rice in Ganganagar since 1985-86. However, in Hanumangarh, it is improving. The yield level in Ganganagar has been reduced to half, from 32 q/ha in 1985-86 to 16 q/ha in 2005. This is not so in Hanumangarh.

Rice is a high water requiring crop and it not recommended to be grown in an arid climate. In fact rice is a semi-aquatic plant and use of water for frequent irrigation in fact amounts to mis-use of scarce water resources of the state. Further, it has been established in many studies that canal irrigation in arid region has detrimental effects on soil productivity and environment. Therefore, the government must think of discouraging such high water requiring crops like rice in the arid region of the state.

Wheat

Wheat, to some extent, is grown in all the districts of the state totaling 20-22 lakh ha. It is entirely an irrigated crop. It is irrigated both from surface and underground water, drawing a lot of groundwater resources and is a cause of concern for depletion of groundwater resources of the state.

Zone I (a) is mainly irrigated from the IGNP system in the arid zone comprising of Bikaner, Barmer, Jaisalmer and Jodhpur. One can say that cultivation of wheat in this zone is comparatively new and started only after the IGNP irrigation system was introduced in these desert districts. The highest yield of 25 q/ha was obtained in Barmer in 1995-96 and over 25 q/ha in Jaisalmer in 2005-06. In Bikaner it remained below 20q/ha at the highest level and even about 11q/ha was recorded in 2000-01. In Jodhpur there has been a steady increase with some decline between 2000-01 and 2005-06.

Zone I (b) of Ganganagar and Hanumangarh is fully canal irrigated. In Ganganagar the highest yield of over 30 q/ha and in Hanumangarh below 30 q/ha has been recorded in 2005-06. In Zone II (a), the trend is on the increasing side with the highest yield recorded in 2005-06 for all the four desert districts. The yield levels varied between about 23 q/ha and 30 q/ha. In Zone II (b), the yield varied between 8q/ha and over 25 q/ha during 1960-61 to 2005-06. Sirohi showed a better performance compared to Pali and Jalore. In Jalore, the highest yield of about 17 q/ha was recorded in 1990-91 and in Pali 19 q/ha in 1995-96. The trend is improving.

Agroclimatic Zone III (a) shows a very wide fluctuation between districts. In Ajmer, the highest wheat yield was obtained at about 17 q/ha in 1995-96, Dausa, the highest at about 37 q/ha in 1995-96, Jaipur at about 28 q/ha in 2005-06 and Tonk at 25 q/ha in 2005-06. The problem of Ajmer needs to be identified with the help of research.

Alwar, Dhaulpur and Bharatpur in Zone III (b) have recorded 35q/ha and above as the highest wheat yield in 2000-01 and 2005-06. Fluctuations are many but the trend is positive and the Zone has potential for sustainable production at still higher yield levels.

In Zone IV (a), Chittorgarh recorded the highest yield of 30q/ha in 2005-06, followed by Rajsamand (28q/ha). Bhilwara and Udaipur never crossed the 25 q/ha level. The linear growth and wide fluctuation requires intervention of research and crop management to increase the levels of production. Under Zone IV (b), Dungarpur and Banswara recorded the highest yield of wheat, 23q/ha at Banswara in 1990-91 and 26 q/ha in 2000-01 in Dungarpur. The periodic fluctuations should be arrested with better water management and input use.

An increasing trend in wheat yields has been seen in Zone V where the highest yields were recorded in 2005-06 at Kota, Bundi, Baran and in 1995-96 in Jhalawar. In this important wheat growing zone, better water management would be helpful in attaining sustainability in production.

Barley

Barley is another important Rabi crop of the state grown on between 1.75 and 2.00 lakh ha more than 90 per cent in the irrigated lands. It is a major crop of Jaipur region.

In Zone I (a), it is grown over 1000 ha in Bikaner and other districts are not important. In Bikaner, the highest yield level of over 22 q/ha was recorded in 2005-06. Barmer with a very low area under this crop (about 60 ha) recorded an yield of 25 q/ha showing a potential in spite of limited available irrigation resources. The general trend is positive and could be considered for expansion of this crop in Rabi with limited water resources.

There is an increasing trend in yield levels of barley in Zone I (b) of Ganganagar and Hanumangarh with the highest yield of 24-25 q/ha obtained in 2005-06. This crop can replace wheat, in some areas, as it requires less water than wheat and has commercial value as well. In Zone II (a), Sikar has the highest area under this crop but yield levels are higher in Nagaur and Jhunjhnu. The trend is of a linear growth and there is a good potential to expand the area for sustainability. In Zone II (b), over 22 q/ha yield levels have been recorded in all the three districts of Pali, Jalore and Sirohi, with Jalore and Sirohi recording the highest yield in 2005-06. With limited irrigation and improved production technology yield levels can be increased, by better on – farm water management and growing of disease resistant high yielding varieties. Barley grown for consumption should have more use of nitrogenous fertilizers as compared to grown for commercial brewing industry.

Jaipur district, in Zone III (a) has over 50,000 ha under barley with the highest yield of over 26q/ha and there is a linear trend since 1960-61 to 2005-06. This shows a high potential for this crop in this district. Ajmer has less than 20 q/ha yield level and Dausa and Tonk above 20 q/ha. The trend suggests a good potential in Dausa, Jaipur and Tonk. Ajmer needs to restructure the cropping pattern during the Rabi season. In Zone III (b), Alwar has the highest area over 15,000 ha followed by Bharatpur. Other districts are not important for barley cultivation.

Bhilwara in Zone IV (a) has more area under barley as compared to Udaipur, Chittorgarh and Rajsamand. The yield level, however, has been higher in Chittorgarh (25 q/ha) and Rajsamand (26 q/ha). Udaipur and Bhilwara never crossed the 25 q/ha level from 1960-61 to 2005-06. The potential does exist to improve and provide sustainability to barley, keeping in view its lower water requirement than wheat.

Dungarpur and Banswara (Zone IV b) are not important for barley but the yield levels show that in Dungarpur productivity can be increased with better input use and water management. In the four districts of Zone V, barley is not an important Rabi crop. The productivity level is less than 25 q/ha recorded in 2005-06. Otherwise, it never crossed the 20 q/ha level.

Gram

Gram is an important pulse crop of the state, grown on about 10 lakh ha, one third of which is irrigated. It needs much less water than other Rabi crops. It is a major crop of Bikaner district and is grown as an irrigated one, followed by Jaisalmer, where it is again an irrigated crop. The irrigation is from the IGNP canal system. In this Zone I (a), the other districts of Barmer and Jodhpur are not of much importance for grain. The major problem of Bikaner and Jaisalmer as well as other districts is a gradual decreasing trend in gram yield levels. The reason for this needs to be examined. One could be poor irrigation management, where over-watering will only produce vegetative growth and low seed setting, resulting in poor yields.

In Zone I (b) of Ganganagar and Hanumangarh, it is mostly grown on conserved moisture and that could be the reason for its unstability in productivity. The yield level in Ganganagar dropped from 750 kg/ha to 500 kg/ha (2005-06) and in Hanumangarh from 550 kg/ha to 250 kg/ha. The area is suitable for encouraging gram cultivation and there is a need to look into the problem of pests and disease and water management to improve and stabilize yield levels.

The Zone II (a), in Churu, it is largely a rainfed crop where as in Nagaur, Jhunjhunu and Sikar, it is a 50per cent to 80 per cent irrigated crop. In Churu it has a declining trend in yield and the area could be diverted to other crops. In Sikar, the highest yield of over 1400kg/ha was recorded in 1985-86 which has

come down to 900 kg/ha in 2005-06. Jhunjhunu recorded the highest yield in the Zone of over 1500 kg/ha in 2000-01 which has come down to less than 800 kg/ha in 2005-06. Nagaur is similar to Sikar. The Zone has potential.

In Zone II (b) of Pali, Jalore and Sirohi, gram is mainly a rainfed crop. The highest yield of nearly 1000 kg/ha was obtained in Jalore in 1995-96. Thereafter, it gradually decreased to 400 kg/ha. A similar trend has been seen in Pali and Sirohi. There is a need of a breakthrough in gram with better varieties showing drought tolerance along with better crop management.

In Zone III (a), Jaipur seems to be the only promising district with some stability in yield levels of gram. In 1970-71, the yield level was over 1200 kg/ha which has come down to nearly 1100 kg/ha in 2005-06. A lot of research and development support are needed to stabilize the yield level of this crop in this Zone.

The five districts of Zone III (b) cover one lakh ha area and less than 30 per cent is irrigated. Bharatpur has shown an increasing trend with the highest yield of over 1400 kg/ha in 1985-86 and 1400 kg in 1995-96. The other promising area is Alwar. The yield is increasing but fluctuations are many and need to be stabilized with better research and development support.

In Zone IV (a), gram is irrigated to the extent of 30 to 33 per cent in Udaipur, Chittorgarh and Bhilwara. In Rajsamand it is not a major crop of the district. Udaipur, Chittorgarh and Bhilwara have shown an improving trend since 1960-61 with Bhilwara showing a greater stability in yield levels. The highest yield of over 1100kg/ha was recorded in Udaipur, followed by Chittorgarh. The region has a good potential for sustainable gram production with better water and input management.

In Banswara, gram is irrigated to the extent of more than 40 per cent whereas in Dungarpur only about 6 per cent (Zone IV {b}). The yield in Dungarpur in 1990-

91 was 1500 kg/ha which dropped down continuously to 600 kg/ha in 2005-06. In Banswara a high of 1200 kg was obtained in 1990-91 which also dropped to a very low level in 2000-01 but increased to 800 kg/ha in 2005-06.

In Zone V, gram is largely a rainfed crop Bundi has shown an improving trend and a greater stability, followed by Baran, Kota and Jhalawar. The improving trend suggests that with greater research and better management yield levels can be increased further.

Mustard

Mustard is a major crop of Rajasthan occupying 20-30 lakh ha and is the largest in area coverage in the country. In productivity, however, it ranks III to V. Except in Banswara and Dungarpur, it is grown in all the districts of the State. It is irrigated to the extent of 80 per cent.

In Zone I (a), the highest yield in all the four districts was recorded in 2005-06 with over 1200 kg/ha in Jodhpur, Barmer and Bikaner and over 1000 kg/ha in Jaisalmer. It is an irrigated Rabi crop and its yield levels can be increased by using better varieties, input use and irrigation management. Pest control is an aspect which needs to be looked into with bio-pesticides. Ganganagar and Hanumangarh have shown an improving trend in productivity with the highest of 1500kg/ha in 2005-06 in Ganganagar and 1100 kg/ha in Hanumangarh. There is great potential to increase yield levels and to provide sustainability to mustard crop in this agrocluatic zone. Water management with water saving devices should be propagated to reduce the cost of cultivation and check the misuse of irrigation water from canal system.

Jhunjhunu and Nagaur in Zone II (a) have shown stability in yield levels in mustard to a great extent. Churu and Sikar have shown stagnation as well as a declining trend. The area in these districts is sizeable, with irrigation facilities.

Therefore, efforts have to be made to stabilize productivity. Alternatively, other crops in Rabi should be considered.

In Zone II (b), Sirohi and Jalore have shown stability in yield levels but in Pali there is a downward trend, where a yield over 600 kg/ha was recorded in 2005-06 against 1200 kg/ha in Jalore in the same year. Constantly low level of productivity in Pali suggests some changes in cropping pattern in the district.

Dausa and Tonk in Zone III (a) have shown greater stability in yield levels as compared to Jaipur and Ajmer. Jaipur has shown wide fluctuation of ups and down since 1960-61. Even with high level of irrigation, Ajmer has not improved. The Zone has positive trend and with improved water management and input and pest control, yields can be increased.

Zone III (b) is a major region growing mustard and all the five districts contribute 7-9 lakh ha area. There is stability in yield levels with an improving linear trend. The yield level, however, needs to be increased for sustainability and greater profitability. Chittorgarh is an important district for mustard and there has been an improving trend in yield levels since 1985-86. The highest of about 20q/ha was reached in 2005-06. Rajsamand and Udaipur are also promising areas but in Bhilwara the yield is only 10 q/ha at the highest level in 2005-06. Production technology needs to be improved, particularly in Bhilwara region. In Dungarpur and Banswara it is not an important crop.

In Zone V Bundi, Baran and Jhalawar are promising districts with the highest yield of about 17 q/ha in Jhalawar (2005-06), followed by Bundi, Baran and Kota. Better varieties and water management may help in improving productivity in this zone.

Cotton

Cotton is an important commercial crop and grown on more than 4 lakh ha with over 90 per cent area irrigated. Even with such large irrigated area, Rajasthan ranks fifth in productivity level in the country. In Zone I (a), it is grown in Bikaner and Jodhpur and the area coverage in Barmer and Jaisalmer is very small. It is fully irrigated in Bikaner and Jodhpur as well as in other districts. Both Bikaner and Jodhpur have shown a rise in yield levels with less fluctuation because of irrigation. Therefore, to reduce the cost of cultivation, increase yield levels and provide sustainability to production, irrigation management, with water saving systems like sprinkler should be encouraged.

Ganganagar and Hanumangarh contribute about 3.5 lakh ha out of a total 4.6 lakh ha area under cotton and out of 6 lakh bales, contribute about 4.5 lakh bales in production in Zone I (b). The entire area is canal irrigated. Ganganagar showed an improving trend from 1980-81 to 1990-91. Thereafter, there has been a decline in yield. Hanumangarh has shower an improving trend and recorded over 400 kg lint per ha in 1995-96. Total improvement in agronomy, including water management can increase and provide stability to yield levels in this zone. Nagaur in Zone II (a) is important but in other districts of the zone, cotton is not grown to appreciable leveler. Yield levels, however, in Nagaur showed a declining trend after 1990-91 whereas it shows improvement in the other three districts and can be encouraged. In Zone III (a), Ajmer is a major cotton growing district but productivity levels have been low as well as shown a declining trend whereas in other districts, the yield has shown an improving trend. Cotton, in Zone III (b), is only grown in Alwar district which has shown a declining trend since 1995-96 where as Bharatpur has given a better performance from a small area under cotton. Efforts to improve productivity in Alwar should be made. In Zone IV, out of Udaipur, Bhilwara, Chittorgarh and Rajsamand, cotton is grown on a large scale only in Bhilwara district and to some extent, less than 1000ha in

Chittorgarh and Rajsamand districts. In improving trend in productivity is seen in Bhilwara and efforts should be made to stabilize cotton yield in the district. Chittorgarh and Rajsamand are also promising districts. Banswara is an important cotton growing area in Zone IV (b) and has given a good performance in yield levels.

In Zone V cotton is not grown on any appreciable area.

Minimizing Water-need for Irrigated Areas for Sustainability

The 'water-crisis' which developed after the refusal of Punjab Government to provide the agreed amount of water to Rajasthan, took a political, economic, social and technical dimension. In this study, we deal with some technical considerations only, purely from the use/mis-use point of water for agriculture.

Water can be a boon as well as a curse, depending on its management. It is worthwhile to mention about the experience of Punjab and Haryana, with a very high percentage of irrigated area and considered to be the 'granary' of India after the Green Revolution. In a short span of only 30 years after the Green Revolution, the productivity of crops in these agriculturally advanced states have started to show a declining trend. The pillars of the Green Revolution were water, fertilizer, seed and price. The indiscriminate use of water and fertilizers showed their ill efects in terms of stagnation/decline in productivity of crops like paddy and wheat with gradual erosion of farmers' income. A technical Fact Finding Committee listed the following causes for the declining crop productivity trend in Punjab and Haryana:

i. Easy availability of surface irrigation and excess exploitation of ground water to get maximum output for economic gains in an intensive rice-wheat

cropping pattern adopted by the farmers for a long period. The over-use of water has resulted in water-logging and development of salinity in the soil.

ii. Farmers shifted to high-value high yielding crops lilke wheat, paddy, sugarcane and cotton as abundant power and irrigation net works were made available. Taking into account the agro-climatic conditions of the area, the availability of subsidy on inputs also tempted farmers for larger use.

iii. Farmers left the age-old traditional and time-tested practices like use of organic manures, green manuring, inter-cropping with legumes, systematic crop rotation etc.

iv. Cultivation of cereal after cereal resulted in deterioration of overall soil health and disturbed the Carbon-Nitrogen Ratio (C:N ratio) and reduced the nutrient and moisture holding capacity of the soil.

v. The assured market intervention (procurement through Government agencies) in respect of rice and wheat in a cyclic manner. This has been reflected in a higher consumption of fertilizes and pesticides along with water to achieve the increased levels of production of crops.

The major cause affecting production and productivity of crops was considered to be the reduction in organize carbon content in soil from 0.5 per cent to 0.2 per cent. This resulted in a reduced water and nutrient holding capacity and overall in soil fertility.

Rice is grown in temperate to tropical climatic conditions. The critical mean temperature for flowering and fertilization ranges from 16°C to 20°C, where as during ripening, the range should be from 18°C to 32°C. Temperatures beyond 35°C affects not only pollen-shedding but also grain filling. Broadly speaking, for vigorous vegetative growth, moderately high temperatures are required,

whereas for panicle initiation, slightly lower temperature (20°C-22°C) would be ideal. High temperatures and high light intensity adversely affect grain-filling.

Rice belongs to the grass family like jowar, bajra, maize, wheat, barley, etc. but is a semi-aquatic plant and its water requirement is higher than that of other cereal crops of similar duration. Figures ranging from 1000mm to 2000mm of water have been reported from various locations in India as the water requirement of rice varies owing to different soil and environmental conditions. In lighter soils water losses amount to 60 per cent of the total water requirement. Losses due to evaporation depend upon the climatic factors and range from 20 per cent to 40 per cent.

The gross irrigated area in rice of the state is 63.93 lakh ha (2003-04) with a maximum of 16.02 lakh ha in Ganganagar region comprising of Bikaner (2.66 lakh ha), Ganganagar (7.4 lakh ha), Hanumangarh (5.38 lakh) ha and Churu (0.56 lakh ha). The lowest of 1.62 lakh ha is in Udaipur region. The rice situation of Rajasthan is given below.

Table 17

Rice Situation of Rajasthan (2004-05)

District	Area (ha)	Irrigated Area (ha)	Percentage of Rice Irrigated	Yield (kg/ha)	Sources of Irrigation system – Major
Ganganagar	2383	2383	100.00	2410	IGNP, Gang, Bhakra
Hanumangarh	17590	17590	100.00	3637	IGNP, Bhakra
Kota	5018	4972	99.08	2150	Chambal, Wells
Bundi	6053	6053	100.00	1850	Chambal, Wells
Banswara	31322	87	0.27	659	Canals, Wells, Tanks, others
Dungarpur	25153	711	2.83	806	Canals, Wells, Tanks, others
Udaipur	5564	1	0.01	749	Canals, Wells, Tanks
Bharatpur	1354	1346	99.40	891	Wells

Source: 1. Vital Agriculture Statistics 2005-06, Directorate of Agriculture, Government of Rajasthan, Jaipur

The yield levels in the surface irrigated areas by major irrigation systems are much higher as compared to well irrigated areas. This is because rice loves water but in arid climate it requires much more water but any excessive use of water creates problems of soil health and environment.

Barah (2004) studied the changing pattern of rice economy in India. He found that after 1970s there was a declining trend in compound growth rate in rice yield in Punjab and Haryana. In fact in 1990s in Haryana it came down to -1.64 per cent and in Punjab just 0.02 per cent. The situation in Rajasthan shows large fluctuations and instability in rice production as shown below:

Table 18
Compound Growth Rates of Rice in Rajasthan

(per cent)

Item / Period	1960-61 to 1969-70	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1998-99	1999-00 to 2007-08
Area	0.53	5.42	-3.15	3.16	-5.66
Production	-3.54	4.92	-1.86	4.55	1.41
Yield	-1.32	1.28	-0.72	1.36	6.14

If we see the earlier Table-18 to, it shows that the area has constantly decreased from 2000-01 to 2005-06 in Bundi (from 47,883 ha to 8788 ha), Kota (7508 to 6642 ha), Ganganagar (4588 ha to 2897 ha), and Hanumangarh (33,537 ha to 16969 ha). In case of Banswara the area fluctuated between 30,000 ha to 40,000 ha. Dungarpur showed an improving trend but almost stagnations in Udaipur. This again depends on the canal irrigation and rainfed conditions. The main sources of irrigation in Ganganagar and Hanumangarh are Gang canal, IGNP and Bhakra, whereas it is Chambal and wells in Kota and Bundi. In Banswara, Dungarpur and Udaipur, canals and wells are main sources. Wells are the only source of irrigation water in Bharatpur.

With the availability of canal water, cropping pattern of irrigated areas of major projects has undergone a drastic change for wheat, rice, cotton, groundnut, sugarcane and spices like cumin, chillies and vegetables. To get the maximum benefit out of irrigation, farmers tend to over irrigate their crops. In the total cost of cultivation, irrigation water is considered as almost a free input or costs very little, as it is not given on volume basis. This also results in low irrigation efficiency on account of non-ET losses (non – evapotranspiration losses like conveyance and seepage losses).

The potential negative environmental impact of most large scale irrigation projects include water-logging and salinisation of soil, increased incidence of water-borne and water related diseases, resettlement or changes in the life style in local people, increase in incidence of agricultural pests and disease out breaks, changes in the land use and cropping pattern, possible destruction of indigenous plant species native and well adapted to local harsh conditions, loss in animal population owing to destruction of their natural habitat and various social impacts associated with changes in the economy of the region. According to Singh (1997) and Garg and Bhargava (2001) the rise in water table in IGNP and Chambal command area has been alarming, large areas have been affected by water-logging and soil salinity. Recently in 2008, Ministry of Water Resources, Govt. of India sponsored a study on the Impact of IGNP Canal on agriculture and socio-economic conditions of people living in that region. The study has conclusively shown the negative aspects of irrigation along with advantages in increase in production and income of people, directly and indirectly.

Studies conducted in arid zone of the state (Narain, 2007) indicates that economic water use (Profit Rs./m^3 water) was highest for green gram (8.33) followed by mustard (6.70), pigeon pea (5.03), gram (4.00), guar (3.89), barley (2.88), wheat (2.80) and cotton (1.92). It has also been suggested that high water requiring crops should be substituted by pulses, and 50 per cent area under cotton and 20

per cent under wheat should be replaced by low water requiring crop like pulses. Such restructuring of the cropping pattern will also increase the size of the command area and will ensure irrigation to 'tail' end farmers.

This clearly brings out that from the agro-climatic situation of the state and also from the scarcity of water, paddy and sugarcane are not suitable crops. Similar findings have emerged from a recent study of 2008 sponsored by the Ministry of Water Resources and conducted by Rajasthan Grammothan Sansthan, Jaipur for IGNP areas of Rajasthan.

There is a need to look at those crops which have the maximum output per drop of water. The system includes following components.

i. Rational exploitation and utilization of water resources.
ii. Irrigation engineering and new techniques.
iii. Agronomic water-saving practices.
iv. Water saving management measures.

Water-saving agriculture would mean obtaining higher crop productivity with a good quality produce and high water-use efficiency. In this way sustainable agriculture can be achieved. It will require better water management, soil amelioration, adopting a farming system approach with improved agronomic practices towards better soil and water conservation.

Some suggestions are given below to check the abuse of scarce and costly irrigation water and to improve soil health and water use economy in the state as long term measures. These are:

1. In irrigated areas of arid region there is an immediate need to restructure rice-sugarcane-wheat based cropping pattern to low water requiring crops like pulses, oilseeds, maize, etc.
2. Encouragement to be given to farmers to grow more of pulses by enhancing minimum support price, covering risk through crop insurance and providing inputs like phosphatic fertilizes and bacterial culture of quality.
3. Pulses to be taken as inter-crop like gram with wheat and legumes with oilseed crops.
4. Research should develop eco-friendly weed control techniques in legume-cereal inter-crop situation. Use of bio-pesticides should be encouraged.
5. Research to develop better drought tolerant high yielding varieties of crops, particularly pulses.
6. In irrigated areas the age-old practice of green-manuring should be revived for sustainability of crop production. The practice of green manuring was given up due to intensive agriculture and paddy v- wheat rotation under irrigated conditions. There was no time left to raise and decompose a green manure crop I the field. Seeds of green manure crops should be produced and provided at incentive price to farmers.
7. In all irrigated areas water management training to farmers should be organized and use of water saving devices should be encouraged. Incentives on drip and sprinkler systems are already available. They should be expanded, so that the flow irrigation practice is minimized for overall water economy and improving crop production. Quality of equipment is very important to get farmers' confidence in the system for continued use.

It is worthwhile to relook at the recommendations made by the National Commission on Agriculture in 1976 which related to sustainable crop production. These were:

(a) "Cultivation of pulses/leguminous crops in rotation or as intercrop is recommended in canal irrigated tracts for the purpose of green manuring and maintenance of soil fertility".

"Scientific investigations into the subject of multiple cropping and crop rotation in the various parts of the country have yielded valuable data on new pattern of cropping suitable to the respective areas. There is now a pressing need to make a reappraisal of the various possibilities to evolve cropping systems for covering all kinds of soils, rainfall and irrigation conditions as obtained in every *taluk.* The cropping pattern systems so determined should be put into operation through active extension efforts and there should be a machinery to assess the progress and to effect mid-course alterations according to need."

Correlation between Rainfall and Yield

Bajra

Comparing the correlation coefficients of Bajra for the three periods for different agro climatic zones, it is observed that in Zone I-a for 1981-90, 67 per cent of the variation in the yield was owing to rainfall pattern and there is 90 percent probability of it being true. Comparing other districts in Zone I-a, only 18 percent variation in the yield is explained by rainfall pattern in Jaisalmer, whereas, Barmer and Bikaner show a 45 percent and 25 percent variation in yield respectively owing to rainfall variations. But these are not significant. For the period 1991-2000, it is observed that in Jodhpur, in 1981-90, only 3 percent variation in yield can be explained by rainfall. Bikaner and Jaisalmer show a

negative correlation between rainfall and yield. 30 percent variation is explained in Barmer and it shows a positive correlation. On the other side, for the period 2001-2006, as the rainfall size is small than other two periods, a positive correlation is observed for all the four districts of the zone. But in Jodhpur only 7 percent variation in yield is explained owing to rainfall variations.

Taking Zone II a for 1981-90, though a 92 percent variation is explained in Jhunjhunu but it is not significant whereas 54 percent variation is explained in Nagaur but there is a probability of 95 percent of it being true. 44 percent variation is explained in Churu and it is significant at 1 percent level. Thus there is 90percent probability of it being true.

Comparing Jhunjhunu for 1991-2000, only 7 percent variation is explained, whereas 22 percent is explained in Churu and Nagaur. For the period 2001-06, 66 percent variation is explained in Nagaur, and 58 percent, 52 percent respectively in Churu and Jhunjhunu. Jalore, from Zone II b, has a positive and significant correlation for all the three periods and 75 percent, 43 percent and 12 percent variation, is explained by rainfall in yield in the periods 1981-90, 1991-00 and 2001-06 respectively. In Zone III-a and III-b, Jaipur shows a negative correlation for the period 1981-90 while Alwar shows a negative correlation for the period 1991-2000. But only 17 percent in Jaipur and 6percent in Alwar, in the respective years, relationship is explained.

Thus, if all the zones are compared,it is concluded that the districts have a positive correlation between rainfall and yield for Bajra. Apart from this, Jodhpur, Nagaur and Jalore are important districts for Bajra. This is owing to the consistency in actual rainfall pattern with respect to the normal. The rainfall has been consistent and nearly to normal for the different periods in Jalore and this has been the reason for the correlation being positive and significant. For other districts, there has been inconsistency in the rainfall pattern and this is the reason that there is a large variation in the correlation coefficient.

Jowar

In the case of Jowar, correlation coefficient for Pali in Zone II- b is significant for the period 1991-2000. 56 percent variation in yield is explained by rainfall, i.e., the yield of jowar depends on the rainfall and the yield is affected by 56 percent owing to rainfall, 60 percent variation in yield is explained by rainfall for the period 2001-06 whereas only 23 percent variation is explained in Pali for 1981-90. In Zone III – a, Jaipur, Ajmer and Tonk, Jaipur shows a negative correlation during 1981-90, whereas Ajmer and Tonk show a high variation during 1981-90. For the other two periods, all the three districts show a positive correlation. For 1991-2000, both Jaipur and Ajmer show a positive correlation and explain 43 percent variation in yield but the coefficient is significant in Jaipur district only.
Kota district, from Zone V, shows a negative correlation during 1991-2000, and for the other two periods, the yield is not affected much by rainfall.

Maize

In Zone IV-a, the correlation coefficient is positive for the periods 1981-90 and 1991-2000 but it turns negative for the period 2001-06 in Udaipur. For the period 1981-90, the correlation coefficient is significant for Udaipur and explains 57 percent variation. It is significant at 5 percent level. For Bhilwara in Zone IV-a, the correlation coefficient is positive for all the periods but it is significant for 2001-06 and a 72 percent variation is explained.
In Chittorgarh, the correlation coefficient is negative for the period 1991-2000 and only 12 percent variation is explained by rainfall in the yields.
In Zone I-b, the correlation coefficient is negative in all the periods for Banswara.

Gram

In Zone I-a, Bikaner has a negative correlation for the periods 1981-90 and 2001-06. For these periods, 62 percent and 24 percent variations in yield respectively

are explained by rainfall. But for the period 1991-2000, the correlation coefficient is positive and only 3 percent variation is explained by rainfall. Thus, the correlation coefficient indicates a negative relationship between rainfall and yield for the above mentioned two periods. (1981- 90 and 2001- 06).

In Zone II-a, Churu has a positive correlation for all the three periods but the other three districts have a negative correlation for one or more periods. In Churu, 3 per cent, 29 per cent and 1 per cent variation in yield is explained by rainfall for the respective periods.

In Jhunjhunu, there is a negative correlation for all the three periods and only 9 percent, 2 per cent and 4 per cent variation is explained for respective periods. Nagaur has a negative correlation for the period 1981-90 but for the other two periods it has a positive correlation. Though in both the periods, 1981-90 and 1991-2000, 6 per cent variation is explained by rainfall in yield but for the period 1981-90, it has a negative correlation and 1991-2000 period indicates a positive relationship between rainfall and yield Sikar shows a negative correlation for two periods, 1981-90 and 2001-06.

Soybean

In Zone IV-a, 47 per cent variation in yield is explained by rainfall variations in Chittorgarh.

In Zone V, for Baran, data were not available for the period 1981-90, and for the other two periods, 1 per cent variation is explained for the period 1991-2000 whereas for 2001-06, 64 per cent variation is explained.

For Jhalawar in Zone V, 1981- 90 period show a negative correlation and 1991-2000 a positive correlation but both explain a 12 per cent variation. For the period 2001- 06, 41 per cent variation is explained with a positive correlation.

Urad

In the period 1981-90, among the Zones IV-a and IV-b, a 34 per cent variation is explained in Dungarpur among the five districts, 23 per cent in Bhilwara, 21 per cent in Udaipur. In Dungarpur, there is a maximum influence of rainfall on yield.

For the period 1991-2000, a 61 percent variation in yield is explained by rainfall variation in Udaipur and there is a significant relationship. But for Dungarpur, it explains only 6 per cent.

For the period 2001-06, there is a negative correlation for all the districts except for Bhilwara.

Dungarpur has the maximum value for the coefficient of determination while Chittorgarh has the minimum. Thus it can be interpreted that production in Dungarpur largely depends on rainfall, which in turn gives a positive correlation between rainfall and yield, whereas, Banswara shows a negative correlation for all the three periods implying that with the increase in rainfall, the productivity is not influenced much.

Moong

Taking the case of Moong, the coefficient of determination for Jalore, Churu, and Jhunjhunu are 0.81, 0.61 and 0.56 respectively. This implies that in these districts 81 percent, 61 percent and 56 percent variation in productivity is explained by rainfall variation. Apart from this Jaipur shows a negative correlation between rainfall and yield for the period 1981-90.

For the period 1991-2000, Sikar shows a 75 percent variation in yield due to rainfall changes. Jalore, Churu and Jhunjhunu show a positive correlation between rainfall and yield. A 48 percent, 18 percent and 57 percent variation respectively in yield is explained by rainfall in these districts, while Jaipur also shows a positive correlation for this period and explains about 49 percent

variation in yield. This gives an absurd result, the reason being an erratic rainfall pattern.

For the period 2001-06, in Jalore, Churu and Jhunjhunu 68 percent, 52 percent and 48 percent variation in yield is explained by rainfall variations.

Moth

For the period 1981-90, Jodhpur explains maximum of 53 percent variation in yield due to rainfall while in Nagaur only 18 percent variation is explained. Both of the districts along with Barmer, Bikaner, and Churu show a positive correlation between rainfall and yield.

But for the period 1991-00, Bikaner shows a negative correlation and all the other districts show a positive correlation. 45 percent variation in yield due to rainfall is explained in Churu while in Jodhpur only 3 percent variation is explained.

In 2001-06, all the districts show a positive correlation but coefficient of determination is the highest in Churu where a 60 percent variation in yield is explained by rainfall.

Conclusion

From the above it is concluded that the correlation between rainfall and yield is positive and significant for all those districts, which are rainfed. But districts which mainly depend on irrigation do not show a significant correlation between rainfall and yield. The positive correlation shows that with the increase in rainfall, the productivity also increases and vice-versa. As can be observed that in good rainfall areas even a lesser amount of rainfall will give good production in turn increasing the productivity to a great extent but in draught prone areas even a good rainfall will not increase the production to a great extent. This is the

reason of correlation being negative in these areas between rainfall and yield. Other than this there are very high fluctuations in rainfall patterns, which insignificantly affect the yield of a particular crop in a particular district. For example, bajra is a rainfed crop. Therefore, in Jalore the correlation between rainfall and yield is significant and highly positive as the production is affected by rainfall, while in Kota, which is an irrigated land and is not greatly dependent on rainfall, bajra does not show a significant correlation in rainfall and yield.

Rainfall and Production

Bajra is a major kharif crop for Rajasthan. Although almost all the districts had good rainfall for the period 1975-76, the production was low because it bajra does not require a large amount of water for production. The reason for low production might be the heavy rainfall is 1975–76 which might have caused the problem of water logging resulting in a lower level of production.

Jowar, another kharif crop, also faced the same problem especially during 1975–76. In spite of good rainfall, the production level was low.

Maize also showed an average production level, for 1975-76, when the rainfall was good but the production was average. Utilization of conserved moisture might be the reason for this.

Guar showed a very low production, except for Jhunjhunu which showed an average level of production.

Gram showed a very good level of production with rainfall, but in Bikaner in 1975–76, the level of production was very low.

Wheat, majorly an irrigated crop showed a consistent increase in the level of production for all the periods in almost all the districts.

Mustard showed a very low level of production till 1979-81. After that it showed a slight and consistent increase for other periods. However, the amount of rainfall was average or good for the periods.

Horticulture Development

Horticulture development was part of Agriculture Development for long. However, in 1989, the Government of Rajasthan carved out the Horticulture Department to give adequate thrust and attention to this subject for a sustainable development in the state. Authentic long term availability of data on fruits, vegetables, medicinal and aromatic plants has been a constraint in making planning and projections a difficult task. This has been so more for district level data. Since 1983-84, state level and from 1999-2000 district level data on fruits and vegetables have become available. The approximate area and the production of fruits and vegetables from 1983-84 to 2006-07 show that the area under fruits increased from 0.051 lakh ha to 0.276 lakh ha. It shows that in 23 years only 0.225 lakh ha area increased at the rate of only 0.0097 lakh ha per year. According to the land use pattern data of Rajasthan, the area under 'Misc tree crops and groves/gardens was 9,000 ha in 1970-71 which increased to 12,417 ha in 2003-04, and 20,118 ha in 2006-07, an increase in 36 years of 7701 ha or a grown rate of 213.91 ha per year. The region-wise data for 2006-07 is as under:

Region	Area under Misc tree crops & groves (ha)
Jaipur	1666
Bharatpur	1635
Ganganagar	8256
Jodhpur	1717
Kota	3524
Udaipur	2758
Bhilwara	562

Source: Statistical Abstract, Rajasthan 2009, Directorate of Economics & Statistics, Govt. of Rajasthan, Jaipur.

This reveals that the largest area is in the higher rainfall part of Udaipur and in Ganganagar where water availability is assured from canal irrigation.

Area under vegetables was 0.379 lakh ha in 1980-81 which steadily increased to 1.229 lakh ha in 2006-07. In case of production, there was a gradual increase with increase in area, both under fruits and vegetables, except that in 2002-03, fruits had the lowest production since 1994-95 and vegetables since 1980-81 (1.052 lakh tonnes). Both the years were severe drought years. The state Government in the Tenth Plan had made projections of area under fruits at 0.64 lakh ha but the actual achievement was 0.238 lakh ha. So was the case for production projections which was 4.80 lakh tonnes whereas the actual achievement was 2.569 lakh tonnes.

The district-wise scenario is very disturbing, as there are wide variations in the area and the production year to year (Appendix -). The district – wise data are available for 1999 – 2000 to 2006 – 07 only.

Area under fruits is the highest in Jhalawar, which increased from 4338 ha in 1999–2000 to 5939 ha in 2002-03, 6275 ha in 2003–04 and 7371 ha in 2006–07. Highest production of 5.36 lakh tonnes 5939 ha in 2002–03 was also in Jhalawar. As far as the production is concerned, 299787 tonnes in 1999–2000 was produced in Ganganagar where it gradually decreased to 48333 tonnes in 2001 – 02 and no production was reported for 2002–03. In case of Chittorgarh, production of 3.42 lakh tonnes has been reported in 1999–2000 from 1229 ha, which increased to 4.09 lakh tonnes in 2000–01 from 1296 ha and 1.07 lakh tonnes from 1316 ha in 2002–03. It is difficult to systematically analyse and make valid inferences from the data on horticulture, both for fruits and vegetables.

After the establishment of the Horticulture Department, some concerted efforts have been made to develop fruits, vegetables, and spices, medicinal and aromatic plants. Varied agroclimatic conditions provide an opportunity for the production

of different types of horticultural crops. This has been indicated by the department and needs to be perused. A SWOT analysis of horticulture in Rajasthan has also been made by the department and this will guide the future requirements for development. This is given as under:

Strength:

1. Favorable climate for production of quality seed spices, mandarin, kinnow, pomegranate, ber, aoula, etc.
2. Available surplus in spices, onion, peas and cucurbits.

Weaknesses:

1. Lesser availability of quality planting material of fruits, quality seeds of spices and vegetables.
2. Acute shortage of water which also is of poor quality.

Opportunities:

1. Ample scope in area expansion of fruits.
2. Potential to increase production and exports of seed spices.
3. Vast potential of medicinal and aromatic plants.

Threats:

1. High cost of production, poor price stability and lack of remunerative prices.
2. Frost during winter, high wind velocity with high temperatures in summer.

There could be some addition in this like the existing surplus of water melons and musk melons, need of regulated markets, processing facilities in production areas, cooperative societies, adequate research support, development plans of horticultural as per agroclimatic zones, soil and water conservation measures at field levels, water management techniques, dovetailing horticulture development with programmes of DPAP, DDP, IWDP, etc.

Greater emphasis should be given on organically produced fruits, vegetables and spices. For this more efforts are required to produce FYM and compost at village levels along with vermin compost. Organized farming involves field management, bio-fertilizers, bio-pesticides, irrigation with pollution free water and a complete ban on the use of sewage water carrying a large number of toxins. The department has a responsibility to make growers aware of pollution and the danger to health from the consumption of fruits and vegetables grown with large doses of inorganic fertilizes, chemical pesticides, polluted irrigation water etc. The soils and irrigated water should be analyzed periodically for taking remedial measures.

For the development of horticulture, specific areas have been identified. Some of these are listed below:-

i) 'Chaitri' roses could be organized to develop rose based agro-industries to promote rose cultivation in Haldighati. Similar efforts in an organized manner can be taken in Pushkar area for rose cultivation.

ii). Mewar and Hadauti regions are quite suitable for horticulture development, particularly citrus fruits, mango, guava, etc. and can be developed as the 'Fruit Bowl' of Rajasthan.

iii) Rajasthan has an ideal climate, both in plains and in a high attitude area like Aravali hills for growing a variety of selected medicinal and aromatic plants as

well as floriculture. Herbal gardens can be developed at a number of places under different agroclimatic regions.

Competitive horticulture cannot be developed without establishing high-tech research as well as commercial facilities like tissue culture laboratories, green houses, poly houses, sanitary and phytosanitary laborites, public private partnership, processing facilities, etc. Some measures have been initiated under the National Horticulture Mission but the state has to do much more to get the maximum advantage of this scheme. A recent study on the feasibility check for diversification towards horticulture production (Mittal, 2009) has cautioned that the re-allocation/diversification of land should be done in a manner such that optimal output and income can be generated, keeping in mind the demands and improvement in the economic conditions of farmers.

A number of State Schemes and Centrally Sponsored Schemes like the National Horticulture Mission are in operation during the last few years. These schemes cover large areas where concerted efforts are required. However, to provide sustainability to production of horticultural crops, integration of various programmes which are land based, provision of adequate market support, cold storages in villages for perishables, processing facilities in production centres, price support, etc. would be required with adequate research support and staff for implementation and monitoring of programmes.

Constraints in implementation of horticulture development have been listed by the department. Poor organizational support and no separate cadre control are the major bottlenecks in taking horticulture to its potential.

There is no point in taking up ambitions programmes of development if adequate staff support of qualified specialists is not provided. Horticulture can be a big revenue earner for the state and can support the required increased staff. Government must think in this direction.

App- IX

Area and Production of Fruits and Vegetables in Rajasthan

Area in Lakh ha
Production in Lakh tones

Year	Fruits		Vegetables	
	Area	**Production**	**Area**	**Production**
1980-81	NA	NA	0.379	1.052
1983-84	0.051	0.348	0.447	1.293
1990-91	0.211	1.045	0.590	3.000
1993-94	0.208	2.505	0.673	3.631
1994-95	0.198	2.296	0.676	2.833
1995-96	0.197	2.384	0.759	3.569
1996-97	0.209	2.671	0.826	3.982
1997-98	0.203	2.180	0.821	3.239
1998-99	0.205	2.383	0.992	3.961
1999-00	0.203	2.408	0.943	4.434
2000-01	0.206	2.380	0.903	3.651
2001-02	0.219	2.007	0.998	4.338
2002-03	0.223	1.892	0.909	3.341
2003-04	0.232	2.208	1.103	5.007
2004-05	0.238	2.569	1.166	5.842
2005-06	0.254	4.185	1.209	7.408
2006-07	0.276	4.021	1.229	7.883
Total	**2.333**	**25.378**	**10.096**	**44.197**
Average	**0.208**	**2.34**	**0.860**	**4.027**

Source: 1. Directorate of Agriculture, Jaipur
2. Directorate of Horticulture, Jaipur

Achieving Sustainability in Agriculture Sector – Policy Issues

Government policies are necessary to guide the developmental activities in the right direction and to provide a coordinated approach. Agriculture is a state subject and the primary responsibility of agriculture development lies with the state. For developing policy issues for sustainable agriculture development a SWOT analysis will help to provide a realistic and logical policy framework. This is discussed below.

Strength	Weakness
- Soil, Water, Plant and Animal Diversity – Arid & Semi arid conditions - High potential for animal husbandry particularly in Western region. - Vast potential of horticulture: arid fruits, seed spices, medicinal and aromatic plants - Food processing: fruits and vegetables - Animal waste processing - Animal produce based industries: wool and carpet industries - Dairy based industries - Regulated market network and cooperative structure - Research support: State Agriculture Universities, CAZRI, and General Universities.	- Large Arid and semi arid regions - Low rainfall: large rainfed agriculture - Water scarcity, over exploitation of groundwater - Low Gross Capital Formation in agriculture - Over exploitation of agriculture - Poor basic rural infrastructure in rural areas - Lack of marketing avenue and storage space - Lack of post – harvest management - Very poor agro- processing facilities - Inadequate and skewed flow of farm credit - Weak Research – Extension – Farmer linkages - Inadequate trained human resources - Poor data base for horticulture - Low investment in animal husbandry sector - Sectoral planning in agriculture & allied sector.

Threats	Opportunities
- High rate of population growth. - Declining / deteriorating natural resource base. - Low crop yield and high cost of cultivation. - Misuse / abuse of ground / surface water. - Second generation problems in canal irrigated areas. - Droughts. - Pollution. - Lack of awareness for WTO provisions. - Slow flow of knowledge TRIP fall out.	- Watershed development in rainfed areas. - Vast potential in animal husbandry sector. - High potential in horticulture crops: seed spices, vegetables, arid fruits, mushroom, flowers. - High realizable crop yield. - Modernization of agricultural markets. - Panchayati Raj institutions. - Planning and funding as per agroclimatic needs.

Overall strategy for Sustainable Agriculture

An overall strategy is suggested to achieve integrated land and water management for eco-sustainable land use and diversification of other activities allied to agriculture sector. The main features of the strategy are: -

- Watershed development with water management, including rainwater harvesting.
- Conjunctive use of surface (canal) and ground water.
- Ground water regulation and recharge.
- Improving soil health and reclamation of saline soils.
- Wasteland development for fodder, fuel, and fruits and afforestation.
- Development of horticulture and live-stock activities keeping in view agro-processing and export opportunities.
- Rationalization of cropping and crop diversification.

- Dissemination of dry farming technology with traditional practices.
- On the lines of the National Food Security Mission- Wheat and Pulses, the State Government should set up a similar Mission of Millets (Bajra, Jowar, and Maize) and pulses to achieve the desired goals on Food Security.
- Comprehensive development of high-value crops like spices and medicinal plants, mushrooms, etc.
- Development of crops and cropping system as per agroclimatic sub-zones for location specific technologies.
- Providing easy access to market and remunerative prices to farmers, if necessary, state minimum prices, to farmers to keep their interest in sustainability.

It is unfortunate that a state like Rajasthan whose economy depend largely on agriculture and animal husbandry does not have a long term policy for the development of these vital sectors of livelihood and economy. All the development programmes and schemes run on ad hoc basis or guidelines from the central government under centrally sponsored schemes. Instead of adjusting their plans, the government should adjust or dovetail central assistance in their own plan. Central assistance should be additive to their own long term state plan and not that state funds for development are with-drawn or curtailed in view of central assistance.

Some broad issues for policy framework are suggested:

1. The policy should address the arid (Desert) and semi-and region separately for priorities and programmes.
2. The policy should deal with irrigated areas and rainfed areas as they have different requirements, constraints and need different plans.

3. Within irrigated areas, surface (Canal) and ground water (Wells) irrigated areas should have specific water management policies to save water and check mis-use of this costly input.
4. The state agriculture policy should address the following issues to develop a holistic and integrated approach of development: -
   a. **State land use policy: -** The policy should address all the types of land available and put a stop to large scale conversion of agriculture land into commercial land. There is nothing like 'Wasteland' which is quickly put to other land use for commercial purposes. Wastelands are not wasted land or barren land where nothing can be grown. They should be put to economic use as grasslands for development of animal resources, arid fruit trees, bio-fuel plantations, etc. All lands should be put to use as per land capability classification for sustainable use. Agricultural land and wastelands must not be converted for any other purpose.

   b. **State water use policy: -** The policy should deal specifically with use of surface water and ground water, so a conjunctive use of water could be developed for maximum benefit. There should be a strict control on growing of high water requiring crops in the state and over-exploration of ground water. Legal provisions should be made to give long term benefits, which may not be popular at the initial stages. The political will and people's awareness are crucial for the survival of the state. The present state policy does not address clearly issues like enforcement of policy provisions with penal processions for defaulters, ground water mining and ground water use regulations, ownership of ground water, water pollution, equity in regulated water use, water rates, etc. Like 'Narbada' experience of Gujarat, it should be made mandatory to use water saving devices like sprinkler and drip irrigation in all canal irrigated areas, both old and new. There should be water zoning of the

state and the economic activities should be guided and regulated in accordance with such zoning.

c. **Rainfed Agriculture Policy: -** Rainfed agriculture must be given priority in all policy guidelines. Rain water management through water harvesting structure, recharge of ground water aquifers and in situ conservation in the field should be taken as a mission under the watershed development programmes for rainfed agriculture. All the fields must be covered with soil and moisture conservation measures and dry farming technology, combining both traditional and the latest proven technologies. The Government should create a conducive environment for greater investment in rainfed agriculture, both public and private for sustainable development.

These major issues will provide a broad canvas to develop details of all the backward and forward linkages for agriculture development. The future should focus largely on employment and income generation through productivity and profitability of the farm produce. The state has a large potential to develop agro-processing industries in this regard. Emphasis and specific plans should be developed for agro-industries like: -

(i) Fruit and Vegetable Processing,

(ii) Dairy Processing, particularly modernization of dairy plants, including involving the private sector, developing and processing of organic milk and its export,

(iii) Cotton and Wool Processing: Up gradation of cotton ginning and wool processing to support cotton and wool industries with better quality finished products

(iv) Slaughter houses: There is great need and demand for modernization of slaughter houses in the state to produce quality meat and meat products for local use and exports. This should be linked with carcas utilization, bone and blood meal manufacture as fertilizes, skin and hides for tanneries, etc.,

(v) Tanneries: All the organized and unorganized tanning centers need improvement in controlling pollution and improving the quality of products,

(vi) Edible oil has a very good potential. The government should encourage improved Ghanis for edible oil manufacture.

(vii) Brewing. Support to brewing industry will help barley farmers as area under barley is declining. This is a low water requiring Rabi cereal and can provide higher income and employment opportunities to farmers and others. (viii) Coarse cereal's industrial use: The food and nutrition security can be strengthened by encouraging coarse cereal production and processing. There has been a decline in utilization of bajra, jowar and barley in the state and as such many a times a glut situation has developed. These cereals, especially bajra is of a low keeping quality. In the year of abundant production, farmers resort to distress sale. Therefore, the surplus production of bajra can be used for manufacture of ethanol. This, may face a stiff competition with ethanol produced from sugarcane in other states. Therefore, a cost-effective method of producing ethanol must be developed in the State as sugarcane factories have closed. Incentives need to be given to industries producing ethanol from bajra within the State. Similarly, the malt industry can also the encouraged by promoting cultivation of barley and providing incentives to malt industry.

The agriculture policy should encourage organic farming with market support and strict quality control needed for credibility in the market. The government should remove some restrictions and reduce on certification.

In addition to the major framework, there are a large number of other supportive areas equally important to make sustainable development a reality. These are briefly mentioned here.

Research Support

The State has an excellent network of agricultural research to tackle the location specific problems of all the identified agro-climatic zones. The State Agricultural Universities at Udaipur and Bikaner are responsible for research, education and extension (Transfer of Technology) all over the State. In each of the ten Agroclimatic zones, there is one Agriculture Research Station and Agriculture Training Centres (ATCs are in 8 zones only). There are Krishi Vigyan/Gyan Kendras (KVK/KGK) in all the districts.

In addition to the two SAUs, the State has an Indian council of Agricultural Research institution, the Central Arid Zone Research Institute (CAZRI), an institution of international reputation at Jodhpur to do the basic as well as applied research in agriculture, agrostology, soil sciences, plant sciences, geo-hydrology, sociology, etc. The research outcome of CAZRI is directly relevant to all the desert districts of the State.

The research efforts in the State are directed more towards crop sciences and not on farming systems for different agroclimatic zones, to integrate animal husbandry, horticulture, fisheries, processing technology, residue management, pesticide residue, bio-fertilizes, bio-pesticides, alternate cropping systems, arid fruits, etc. In conducting research due emphasis is needed to re-look at the traditional cropping practices/systems.

The SAUs are now well equipped and look to future challenges of climate changes, GM crops, provisions of WTO, organic farming, PVP Act 2000,

contractual research, etc. to withstand vagaries of weather and fluctuations of market. A well thought organic coordination is required to do coordinated research programmes with SAUs and ICAR institutes like (CAZRI) in which the State Government should take active interest. This should be based on system approach and not on individual approach. There is a need to evaluate the research of the SAUs in terms of cost-benefit to the states farmers and to see the investment and future requirement of investment in terms of output.

A World Bank Project aims at making use of information, communication technology (ICT) in empowering farmers with better knowledge of crops. This is being done to meet the challenges pertaining to climate variability, degeneration of soil and water, National Innovation Project of the KAR.

Agri-Business

The concept of agri-business has not taken its due place in modern-day competitive world, particularly in Rajasthan. This area needs concerted efforts to provide active support for sustainable agriculture sector development. The concept has to penetrate to the district level for management of agriculture with farmer's participation. According to Acharya (2004), the main factors impacting the demand for agri-business services are: -

a. Increase in urban population.

b. Increase in per capita income.

c. Increase in demand for marketing services like processing, packaging, quality certification and branding.

d. Increase in linkages with distant and overseas markets and consumers.

He opined that there were several agricultural and processed products of Rajasthan which are characterized by 'geographical indication' in the national as well as global markets. Some of these products are moth, guar, coriander, isabgol, garlic, soybean, mustard, methi, sojat ki mehandi, Bikaneri bhujia and rasgoola. Jaipuri Ghewar, Jodhpuri Kachori, Alwar Paak, Sohan halwa of Ajmer, musk melon of Tonk, basmati rice of Bundi, oranges of Jhalawar, malta of Ganganagar and several medicinal plants and herb could also be added. There has been very little branding and patenting of these products. The potential of marketing of these products for increasing the demand and in term increasing the income of rural people and farmers is immense. This will need sustainable supply of raw materials to produce and market them. This has not yet been exploited at the required scale.

Agri-business consortium concept was given in the Eighth Five Year Plan. The M.S. Swaminathan Research Foundation had prepared model project reports for some districts of the country including Bikaner in Rajasthan. On similar lines more such reports should be prepared.

Agriculture Extension

All the development or improvement at field level means transfer of technology (TOT) and information communication technology (ICT) to farmers. The mind-set of agriculture as just a livelihood means depended on the vagaries of the monsoon and the fluctuation of market must go. With so much advancement in science and technology, it is the responsibility of the state to equip its farmers with means and ways to combat adverse situations and to attain sustainability in their lives. 'Knowledge deficit' has been identified by the National Commission on the Farmers as one of major constraints to agriculture productivity collapse of extension services fertilizer subsidies leading to excessive and harmful use of

fertilizers and sub-optimal farming practices are some of the results of the poor access to knowledge. One could add the poor water management as a part of the extension system to impart knowledge on this. According to Adhiguru (2009) the public extension system has been found to be accessed by only 5.7 per cent households. Further, only 4.8 per cent of small farmers have access to public extension system as compared to 12.4 per cent of large farmers. The study has suggested promotion of farmer-led extension and strengthening of public system extension serious to improve coverage and efficiency of agricultural information systems.

The state tried some extension systems in the past but they could not deliver the goods. In the extension programmes, unfortunately the emphasis was given to irrigated areas and not much to the rainfed areas till the watershed development became a major programme. The present agriculture extension largely looks after distribution of inputs like seed, fertilizers, pesticides and miniput demonstration. These are looked after by the Agriculture Department. The foundations of crop production-soil and water conservation measures are with Watershed Development and Soil Conservation Department with a separate Head. In the department, technical leadership is missing to make the best use of modern agriculture systems.

The deficiencies in the present day extension system are:

1. Less qualified grass-root extension personnel.
2. They are Over-burdened with activities other than agriculture.
3. Confession under Panchayati Raj system about work and duties.

4. Over-lapping of extension efforts owing to multiplicity of extension agencies.

5. Extension does not include allied activities like soil and water conservation, horticulture, animal husbandry, poultry etc.

6. Ecology and silvi-pasture are neglected areas in the government.

7. There is hardly any organic coordination between the Agriculture Department, Rural Development Department (Soil & Water conservation & watershed) and KVKs (Research) at the field level for transfer of technology. Only some classroom trainings are held.

8. There is no feed back from the field to make any timely correction. We may develop a regular system for it.

In 2008, a new Centrally Sponsored Scheme, "Support to State Extension Programme for Extension Reform" was launched in the state. Beside much insulation, it has been mentioned in the guidelines that funds should be spent on rainfed areas at least in proportion of rainfed areas in the district.

Further, in addition to crop demonstration, demonstrations on allied sector have also been separately provided for funding.

The beginning is good but again there could be problems in implementation as all the activities suggested come under the jurisdiction of agriculture, horticulture, rural development, animal husbandry & dairy development. An effective and meaningful coordination is required not only at the top but also at lower levels to get the desired results and to achieve the goals set in the agriculture sector.

One of the lessons of the Tenth Five Year Plan is that the absence of adequate incentive structures have led to the break down of extension services in most states. In order to take corrective measures the Government of India launched a new scheme to revamp the extension system. Under that the state Government is implementing a project on a reform of agriculture extension. Under this project at each district level, an authority-ATMA (Agriculture Technology Management Authority) has been constituted to improve the management aspects of agriculture. The main objectives of this is to strengthen agriculture and farmers by providing technical services, organizing farmers groups, providing management awareness and training, etc. At district level the Chief Executive Officer, Zila Parishad, is the Chairman and 12 other members are taken from the concerned departments, research, bank, farmers' representations, etc. In the first, second and third phase of this scheme, all the 32 districts have been covered and their projects sent for approval.

The major issue is how to have an effective and organic coordination of various agencies and dovetailing of schemes at field level.

The Agriculture Department of the state is implementing a number of schemes and programmes to increase production and productivity of crops and providing assistance as subsidizer to the farmers. The schemes are centrally sponsored as well as under the State Plan.

The state plan provides support to production and distribution of inputs like seeds, manures & fertilizes, plant protection, extension, agriculture implements, crop insurance and also provides matching state shares to various centrally sponsored schemes. The schemes are both to strengthen infrastructure and to provide subsidies on various items. The dissemination of technology is through crop demonstration and other extension measures. Now-a-days media like radio

and T.V. are helping in extension efforts. There are Agriculture Call Centers to provide solution to the problems of the farmer.

The centrally sponsored schemes relate to ISOPAM (oilseeds, pulses and maize), macro-management work plan on wheat, coarse cereals, sugarcane, integrated nutrient management, agriculture mechanization and reclamation and development of alkali soils. There is a separate centrally sponsored scheme on cotton under Cotton Technology Mission. The Agriculture Department also implements National Watershed Development Programme for Rainfed Agriculture (NWDPRA), River Valley Project (RVP) & Flood Prone Rivers project (FPRP) along with agriculture based programmes. Expand all these schemes provide subsidies as per the approved pattern.

Under the National Food Security Mission of the Government of India, the State Department is implementing (National Food Security Mission) NFSM-wheat and NFSM-pulses in different identified districts since 2007-08.

In order to achieve the planned four per cent annual growth in the agriculture sector during the 11th plan, the National Development Council (NDC) directed that a new Additional Central Assistance Scheme should be, introduced to incentivise states to draw up plans for their agroclimatic conditions, natural resource issues the and technology into account, and integrating livestock, poultry and fisheries more fully, over and above the existing Centrally Sponsored Schemes, to supplement the state-specific strategies, including special schemes for beneficiaries of land reforms. Further, the newly created National Rainfed Area Authority will, on request, assist states in planning for the rainfed areas. A National Agriculture Development Programme (NADP) has be launched from 2007-08 as a State Plan Scheme. The NADP (RKVY) funds would be provided to the states as a 100 per cent grant by the Central Government. The eligibility for assistance under the scheme would depend upon the amount

provided in the State Plan Budget for Agriculture and Allied sectors, over and above the base line percentage expenditure incurred by the State Government on Agriculture and allied sectors, which includes Crop Husbandry (Including Horticulture), Animal Husbandry, Fisheries, Dairy Development, Agricultural Research & Education, Forestry and Wildlife, Plantation, Agriculture Marketing, Food storage & Warehousing, Soil & Water Conservation, Agricultural Financial Institutions, Other Agricultural Programmes and Cooperation. The States are required to prepare Agriculture Plans for the districts.

As per guidelines, each district will formulate a District Agriculture Plan (DAP) by including the resources available from other existing schemes – District, State or Central Schemes such as BRGF, SGSY, NREGS, Bharat Nirman, etc. The district would aim at moving towards projecting the requirements for development of Agriculture & Allied Sectors within the overall development perspective of the district. The DAP would present the financial requirements and the sources of financing the agriculture development plans in a comprehensive way.

An externally assisted project of Rajasthan Water Sector Restructuring Project (RWSRP) was implemented from March, 2002 to March, 2009. The Agriculture Support Services Component of the project was implemented by Agriculture Department. The major objectives of this project are: -

(i) Strengthen the capacity for strategic planning and sustainable development and management of surface and ground water resources in Rajasthan, and

(ii) Increase the productivity of irrigated agriculture through improved surface irrigation systems performance and strengthen agriculture support services, involving greater participation of users and the private sector in service delivery in Rajasthan,

through the transfer of irrigation management to Water Users Associations (WUAs).

On crop insurance, the state is implementing two schemes viz. National Agriculture Insurance Scheme, Kharif 2003 and Weather based Crop Insurance Scheme, Rabi 2007-08. These two schemes cover all the major agriculture and horticulture crops. The scheme is more beneficial for kharif farmers owing to the vagaries of weather.

Discussion

Agriculture sector is the main stay of the livelihood of people of Rajasthan. The state is not industrially developed and agricultural and animal products provide raw material base to small and medium agro industries. Mining, although provides major share of revenue but its detrimental effects are proving counter productive. The long range damage to over-all environment, including micro-level effects on agricultural productivity, is a cause of concern and a legal issue.

It is a fact that the state has a long history of draughts as its climate is arid to semi-arid with scarce water resources with average rainfall of 550 mm or so. The harsh desertic conditions of western districts covering 60 per cent area make life a struggle for survival for the human beings, animals and vegetation. More than agriculture, animal husbandry plays a vital role in the life of the western region. Wide yearly and seasonal variations in rainfall result in large yearly fluctuations in the production and productivity of crops throughout the State.

In spite of all odds, farmers of Rajasthan managed to increase the productivity of most of the crops as is evident from index number of productivity.

Table 19

Index Number of Productivity of Group of Crops

(Base Year 1991-92 to 1993-94 =100)

S. No.	Group of Crops	2005-06	2006-07
1.	Food grains	108.41	150.70
2.	Cereals	124.71	160.00
3.	Pulses	70.92	127.72
4.	Oilseeds (7-crops)	153.54	156.17
5.	Fibres (Cotton Lint)	101.59	116.22
6.	Condiments & Spices	133.02	169.18
7.	Fruits & Vegetables	137.72	135.81
8.	Guar Seed	112.09	108.31
9.	All Commodities	130.98	145.72

Source: Statistical Abstract, Rajasthan 2009, Directorate of Economics & Statistics, Govt. of Rajasthan, Jaipur

This picture shows that keeping in view the 90˙s as the base, the productivity of group of crops has shown an increase, except in fruits and vegetables and guar seed. As stated earlier the data on fruits and vegetables are not reliable and upto date. Within the groups of crops, there are some variations. The major concern of this study is to identify the crucial areas which can play a vital role in providing stability and sustainability to Rajasthan agriculture based on productivity of individual crops and the sector as a whole. Sustainability in agriculture is looked at with reference to food security, nutritional security and livelihood security and is related with environmental security and life amenities. Thus, the canvas is broad as food includes food grains, milk, meat, eggs fruits and vegetables. A 'Food Insecurity Index' has also been suggested and on this index, Rajasthan is less food secure. Not only agriculture, contribution of animal husbandry has also been important to an improvement in the economy of the state, particularly in drought years. Therefore, the theme includes agriculture and animal husbandry as well providing an integrated approach to sustainable growth in this sector through policy interventions.

Agriculture and animal husbandry sectors contribute about 25 per cent of the Gross Domestic Product (Gross State Domestic Product- GSDP). This sector of economy provides a major share in the State income and employs nearly two-third of the labour force. The contribution of agriculture and animal husbandry sectors in the state economy is shown as under.

Table - 20

GSDP and NSDP of Agriculture and Animal Husbandry in Rajasthan

(in %)

Plan	Agric to GSDP	Animal Husbandry to GSDP	Agric to NSDP	Animal Husbandry to NSDP
VI 1980-85	32.11	8.16	40.42	9.74
VII 1985-90	25.66	8.06	32.81	9.85
VIII 1992-97	25.17	8.20	27.27	8.71
IX 1997-02	18.99	10.03	20.15	10.67
X 2002-07	14.42	9.93	15.58	10.76
XI 2007-12 (2007)	13.98	9.44	14.99	10.21

Source: Directorate of Economics & Statistics, Govt. of Rajasthan, Jaipur (Various Issues)

Dev (2009) studied the challenges of revival of Indian agriculture and quoted the growth rate in NSDP agriculture for all states. The information on Rajasthan is as under.

Table - 21

Growth Rates of Agriculture SDP (Ranked by percentage of rainfed area)

State	1984-85 to 1995-96	1995-96 to 2004-05	Rainfed Area (%)	Net value Added SDP* compound rate	
				1984-85 to 1995-96	1995-96 to 2004-05
Rajasthan	5.52	0.30	70	15.68	2.54 Agriculture
				14.46	12.28 Animal Husbandry
All India	3.62	1.85	60		

* Calculated separately for agriculture and animal husbandry.

According to Dev, the growth rate in agriculture SDP was high in many states and also at the all India level during the period 1984-85 to 1995-96. The growth rates, however, decreased all the states, except Bihar, during the period 1995-96 to 2004-05. The decrease was the highest in the states with greater proportion of rainfed areas- Gujarat, Rajasthan, M.P. Karnataka and Maharasthra. The Net Value Added SDP calculated for some periods for Rajasthan also shows that this was higher from 1984-85 to 1995-96 and decreased in the period 1995-96 to 2004-05. As stated earlier, the GSDP in 1980-81 for agriculture and animal husbandry was 47.83 per cent, out of which animal husbandry accounted for 7.89 per cent. In 1990-91, it was 42.75 per cent for agriculture and animal husbandry and was 7.36 per cent for animal husbandry. In 2002-03, it was 21.58 per cent for agriculture and 12.18 per cent for animal husbandry. In 2007-08 it was 23.42 per cent and 9.44 per cent, respectively. In case of NSDP, animal husbandry proportion was 7.50 per cent in a total of 49.15 per cent for agriculture and animal husbandry in 1980-81. In 2002-03, animal husbandry was 13.21 per cent against 10.03 per cent of agriculture. In 2007-08, out of a total 25.20 per cent, animal husbandry was 10.21 per cent (at current prices). This shows that in a draught year, animal husbandry contributed more to the state economy.

Per capita NSDP and GSDP at 1980-81 prices and 1993-94 prices show that Rajasthan's rank on all India basis in NSDP improved from 26 to 17 in 1990-91 to 1992-93 over 1980-81 to 1982-83. The increase was 28.4 per cent. In the case of GSDP also, similar increases have been reported. Rajasthan's rank was better than the states of Madhya Pradesh, Assam, Orissa, Uttar Pradesh and Bihar. From the poverty point of view, both for rural and urban population, Rajasthan's position is better than the all India average. Amongst the states, Rajasthan's position is better than Bihar, Assam, Orissa, Madhya Pradesh, Uttar Pradesh and Maharasthra.

Kharif cultivation is risk prone in Rajasthan, according to a study based on 2002-03. The gross return per hectare in Rajasthan for Kharif was the lowest in the country at Rs. 271 per hectare only against the all India figure of Rs. 6756 per ha. In case of Rabi, it was Rs. 10954 per ha against an all India figure of Rs. 9290 per ha. It was the highest for Punjab at Rs. 20929 per ha.

The major aim of this study, as mentioned earlier, is to improve the economic condition of the state by providing sustainability to agriculture sector. For this productivity needs to be enhanced and sustained under rainfed condition.

Proper land use is crucial for the economic activities as well as for environmental protection. All the issues pertaining to land use have been studied and discussed by many researchers. Rathore (2007) and Joshi (2007) have suggested changes in the existing system of classification of land use in the context of various development issues including environmental aspects.

At present, there is no land use policy. There is a policy on land but it changes new and then without any scientific considerations.

A land use policy must look into the following suggestions: -

i. All lands should be put to use as per a land capability classification.

ii. There should be separate policies for urban and rural land use.

iii. It is suggested that agricultural lands must not be allowed for sale for purpose other then cultivation. Such transfer should be prohibited by law. If a farmer wants to sell his land, he may first do so to his neighbor farmer or any farmer from the same village. If there is no buyer in the village then village Panchayat may allow sale to a farmer of nearby village.

iv. Similarly, no fragmentation of a holding may be allowed beyond a certain limit like one acre or half acre. In the event of some one dividing his land holding below the limit presented, he should sell the portion to any family member and in case no family member wants to buy, then the Panchayat can decide whom to sell but the land must not be less than the prescribed limit.

v. In the land use policy it should be made mandatory to put land for agricultural purpose and if any reclamation is needed the same may be done. Grasslands and pasture areas are declining. There is an urgent need to see that the common lands or panchayat lands should be properly developed. Some efforts in this direction are going on but there is hardly any follow-up and monitoring.

vi. The land-lease market should be legalized to help in diversification of rural house-hold incomes, bringing existing unused land under productive use, and encourage tiny land holders to engage in other occupation, without fear of loosing ownership rights of land (Acharya, 2009).

vii. Large areas under Indira Gandhi Canal can be developed as grasslands and pastures for development of animal husbandry and animal based agro-industries. This will be a proper use of the land in western Rajasthan.

viii. High water requirement crops like paddy and wheat should not be encouraged in western Rajasthan. From agroclimatic point of view also, nature has not designed these crops for cultivation in this region.

Along with land use, proper water use is closely linked for sustainable agriculture, particularly in a water scarcity state like Rajasthan. The *water use policy* should be separate for irrigated and rainfed areas as suggested below:-

Irrigated areas

i. Surface water (canal) irrigated areas should have a cropping pattern based on low to medium water requiring crops.

ii. Pulses should be given more importance in irrigated areas, in cropping patterns.

iii. Flood irrigation should be prohibited and penalized under law.

iv. The sprinkler irrigation system should be encouraged.

v. Farmers and extension agencies should be given training in irrigation water management in different agroclimatic regions.

vi. Water users associations should be formed in all canal irrigated command areas with power to take decisions as per their needs.

vii. There should be penalty on a user for mis-use of irrigation water.

viii. Ground water exploitation must be stopped with legal provisions for the future.

ix. Recharge of ground water should be a major responsibility of the government.

x. Conservation of surface and ground water can best be achieved when water and power are priced according to the volume of their consumption. This should form a part of the water policy.

Rainfed Areas

i. Water harvesting means should be mandatory for collection, storage and use of rain water.

ii. Massive soil and moisture conservation measures should be taken to conserve each and every drop of water in the field. Farmers should get incentives for contour cultivation and *in situ* moisture conservation practices.

iii. Watershed approach should be adopted on all rainfed areas. The present pace of development has to be stepped up to reduce to 4 to 5 decades, the period for treatment of all rainfed areas of the state. This is the key to sustainable growth in agriculture sector.

iv. In rainfed areas, effective water harvesting of rainfall and equitable, sustainable and efficient use of groundwater needs to be enforced.

The Land Use and Water Use Policies are specific areas of concern and policy reforms are needed for the over all growth of the agriculture sector. There are a number of linked issues which are required in the State Agriculture Policy to provide an integrated approach of development as a system. These have been very aptly suggested by Acharya (2009) Dev (2009) and others. These are:

a) Investment in agricultural research should be increased. There is need to step up research funding in the light of emerging dangers from climate change, usefulness of genetically modified germplasm, need for organic farming, an integrated watershed approach, etc.

b) Investment in agriculture for irrigation, soil and water conservation, integrated natural resource management, and seed production sector is vital for increasing productivity of land, water and crops. Similar investment in rural roads and marketing infrastructure should also be made.

c) Diversification in the agriculture sector has a vast scope for high-value crops in horticulture, live-stock and fisheries. This can raise the agricultural growth rate of the state. It may be cautioned that the diversification should not be at the cost of food security for the state.

d) Since agriculture in the state has a high risk, support for infrastructure, marketing and proper prices of agricultural commodities will provide confidence to farmers in attaining sustainability. These policy issues must be small and medium farmer-friendly.

e) Transfer of technology to farmers with an effective extension system and providing critical inputs to farmers at affordable prices or user chargers.

f) Post-harvest and on-farm handling of farm-products particularly training of more & more small and medium farmers and provision of appropriate technology especially in the rainfed area.

g) Crop insurance in present day agriculture has become equally important in the agriculture sector particularly to cover yield risk in rainfed agriculture. Similar is the case with the animal sector.

h) We may focus primarily on farmers who are small and marginal in the rainfed barani areas, women farmers & women headed households, SC/ST farmers especially in the rainfed areas.

Research in the agriculture sector is the *back-bone* for development and sustainability. SAUs have now taken up research in view of agroclimatic zone characteristics. This is a good beginning and will provide location specific solutions to farmers' problems.

There is a need to look at research priorities. It is felt that there is inadequate emphasis on research needs of rainfed crops. There is a crop bias where small millets and pulses like moth are not given the required attention. Farming system research is ignored which is so important for a rainfed state. Use of indigenous and traditional knowledge needs to be integrated, which in turn can reduce the cost of production and increase the farmer's return. There is a need to develop a new land use system including agro-foresting and allied activities. Organic farming is being stressed so much but well planned true organic farming experiments under different agroclimatic condition are few. At present, a package of practices is just collected and given to farmers. Similarly, to protect our soils or enhance their properties, long term experiments should be done as a part of sustainable agriculture.

The SAUs should plan experiments on climatic changes and their impact on plants, soil properties, bio-diversity, insect-pest and diseases, bio-fertilizes, bio pesticides, fisheries, live-stock health and productivity, etc. There is an urgent need to conduct research and to come up with specific recommendations on contingency planning for crop, horticulture, live-stock and fisheries management, keeping in tune with the behavior of the monsoon rains. This will provide a cushioning effect to the farmer to minimize his losses.

Agriculture is a dynamic process and so is the related research to make necessary changes and modifications. There is, however, a need to give full financial support to research systems with accountability so that funds and efforts give maximum protection to resource-poor farmers.

On the existing Training and Visit (T&V) system of extension, Dev (2009) stated that it is top-down in its approach and there is little participation by the farmers. Further, there is a need to take corrective steps to deal with the near collapse of the extension system in most states. Therefore, there is an immediate need for reforming and revitalizing the existing agricultural system in the country. He suggested the following ingredients for reforms: -

a. Active involvement of small & medium farmers through user groups/associations.

b. Participation by the private sector and NGOs.

c. Increasing use of media and information technology, including cyber kiosks to disseminate knowledge on new agricultural practices and information on output and input prices and

d. Building gender concerns into the system, for example by manning the extension services predominantly by women (Rao, 2005).

Dev also suggested that the returns to investment on research and extension will be much higher on agricultural growth as compared to other investments.

At present the situation in horticulture development is not rosy. Unfortunately, the data base for horticulture is very weak and all the planning is ad hoc. However, some momentum has developed with the National Horticulture Mission. A 4% growth in the agriculture sector can be achieved through promotion of horticulture as a necessary means of agro-diversification for a

second green revolution, particularly in the rainfed areas of Rajasthan. This will provide the much needed impetus to growth through an increase in production, trade, income, employment and agro-based industries. Diversification to high value, low-volume commodities will greatly help small farmers. The cost-benefit ratio of horticulture, particularly floriculture and olericulture for small farmers is more profitable and economically feasible to shift land from cereals to horticultural crops. Some agro-climatic zone-wise recommendations are available for fruit crops. These are required to be refined and made into a system as per the needs of the farmers with backward and forward linkages.

There is an opportunity for the State Government to plan on an integrated and holistic basis for the utilization of all the resources to attain the goal of sustainability on agriculture. A new State Plan Scheme of National Agricultural Development Programme (NADP) or Rashtriya Krishi Vikas Yojana (RKVY) provides the necessary support to the states to step up the slow growth in the Agriculture and allied sectors. The scheme involves a District Agriculture Plan (DAP) based on available national and financial resources. The plan will include animal husbandry and fisheries, minor irrigation projects, rural development works, agricultural marketing, water harvesting schemes, soil conservation, etc. keeping in view the natural resources and technological possibilities in each district. The state has already demarcated ten agro-climatic zones. The planning according to the RKVY guidelines will ensure almost an ACRP approach. There is a well defined monitoring procedure for RKVY. Therefore, it is hoped that this will help in a sustainable development of agriculture in the future.

There is, however, one important point. At present all land based developments are with the Department of Rural Development and all crop based activities with the Agriculture Department. Zila Parishad, under the Department of Panchayati Raj and Rural Development, administers all the schemes and programmes at district level. Thus, the farmer has been bifurcated into two major departments of

the state and there is hardly any organic linkage at the ground level. This has hampered the progress in the agriculture sector. Further, the allied sector of animal husbandry works independently of agriculture sector along with grassland and pasture development is the responsibility of the animal husbandry department.

Under the present system of governance all the sectors work independently. There may be integration at higher levels but the much needed integration at the ground level is missing. Therefore, the state should make necessary corrections in the allied sector programmes keeping a farmer in mind, his natural resources and financial constraints as a background to disseminate technical know-how to him for sustainable development.

There is a serious concern on the current planning process for agriculture development to aim at sustainability. In order to address this issue systematically and scientifically, a new approach to agricultural planning- Agro-Climatic Regional Planning (ACRP) has been suggested (see Mathur, 2005). ACRP is essentially resource-based planning and the rationale of this approach emerges from the significance of long term resource efficiency or sustainability. This approach differs in many ways from the current planning process as shown below:-

S. No.	Current Planning	ACRP
1.	Plan is based on administrative unit.	Plan is for agroclimatic zone.
2.	Top down planning.	Bottom up planning.
3.	Budget oriented.	Issue and problem oriented.
4.	Focus on sectoral component.	Focus on resource endowment, their utilization, constraints and potential.
5.	Ground realities and technology options not considered.	Technology options, ground realties for local needs, knowledge are considered and prioritized.
6.	People's participation lacking.	People's participatory approach for planning, execution and monitoring is ensured.
7.	Private investment and sectorial funding not integrated.	All funding from different agencies is integrated.
8.	Individual department oriented and all agencies not involved from the beginning.	All agencies are involved right from the beginning in the planning process across all concerned departments/ disciplines.

Executive Summary

A study was conducted to identify short comings and constraints in the agriculture sector of the state of Rajasthan and to attain sustainable growth in sector which included animal husbandry and allied sectors. Generally the period of study was from 1960-61 to 2005-06 but as per the requirement and availability of data, the data upto 2007-08 have also been taken into account. The study mainly focuses on the productivity of agriculture and allied subjects which ultimately provides a total production based on input use. The analysis has been made district-wise. The main features with suggestions have been given as under:-

1. The agro-climatic zones showed a wide variation in the productivity of all major crops of the state.
2. There are wide fluctuations in yield levels from year to year in all the districts of the state.
3. There has been a land degradation problem which needs immediate attention.
4. The grasslands of the state have decreased and there is an urgent need to develop/renovate grasslands and pastures to sustain the large animal population of the state.
5. For rainfed areas, development of watershed should be taken with an integrated and holistic approach. The pace of progress in watershed development has to be accelerated to cover the entire rainfed area in the shortest possible time.
6. In irrigated areas, restructuring of cropping patterns is needed to discourage high water requirement crops and increase water use efficiency with water saving devices and imparting knowledge to farmers on water management.
7. For rainfed areas, contingency planning should be an integral part of the extension system to meet any eventuality in case of weather aberrations.
8. Diversification to horticulture, high-value crops, has been suggested, keeping in view the land use pattern so that food grain production does not suffer.
9. Diversification should include animal husbandry under crop-live-stock farming system, particularly in rainfed areas.
10. There is an urgent need to regulate over-exploitation of ground water. However, before attempting drastic measures, necessary alternate

measures must be in place like recharge of ground water, water rates/power rates to check any mis-use of water.

11. Rain water harvesting must be the priority and should be high on the agenda of the State Government for agriculture and drinking water purposes.
12. Industries should be encouraged to make use of solar energy and rain water harvesting to meet at least fifty per cent of their requirements.
13. Institutions like Water Users Association should be formed and given in all powers the irrigation command areas for effective but responsible farmer participation.
14. Watershed Committees should be used for water management in watershed areas.
15. Organic farming should be promoted but should be accompanied by institutional mechanism of certification, pricing and marketing of organic produce.
16. There is a need to revamp agricultural extension system for which the from of ATMA should be taken for all the districts.
17. Agro-climatic zone based planning and integration and dove-tailing/convergence of all agriculture sector based schemes should be made in the DAP as per the suggestions under the RKVY scheme of the centre.
18. The State should formulate a State Agriculture Policy for sustainable development in all the areas of the state. This should include Land Use Policy, Water Use Policy, Cropping System and other areas of marketing, storage, processing, seed production, particularly of millets, pulses, oilseeds, etc.

19. Research should be strengthened and its priorities should be redefined to include the impact of climate change, cropping system in rainfed areas, farming systems, GM crops, organic farming, etc. keeping in view the resources in different agro-climatc zones of the state.
20. Investment in productivity raising infrastructure should be increased, both in the public and the private, in activities like irrigation, soil and water conservation, national resource management, agro-processing, storage, etc. This can only provide the back bone to a long-term sustainable development in agriculture.

Conclusions

The study on 'Sustainable Growth in Agriculture Sector' for Rajasthan has clearly brought out productivity variations of major crops within agroclimatic zones of the state as well as the yearly variations. The arid and semi-arid regions of the state not only have low rainfall but it is erratic, uncertain and gaps make it difficult to successfully raise rainfed crops on a sustainable basis. It has been found that land use, water use and cropping patterns have not been looked as a system for sustainable development. As a result there is land degradation, shortage of water, particularly ground water, inefficient use of surface water and wrong cropping patterns. All these have led to unsustainability and the growth rate in agriculture adversely affected, which very much depends on behavior of monsoon. Degradation of grasslands has further aggravated the problems of availability of grasses for large animal population.

It has been suggested that there is an urgent need to provide direction for sustainable growth in the agriculture sector including horticulture and animal husbandry through a number of policy measures like. State Agriculture Policy including Land Use Policy and Water use Policy. Similarly, there should be

policy measures for Irrigated and Rainfed areas and funding has to be made accordingly to match the requirements. For irrigated areas, paddy and other high water requiring crops should not be encouraged. The limited irrigation water must be used to raise the productivity of low water requiring crops like millets, pulses and oilseeds. Water Users Associations should be formed for efficient management of irrigation water from canals. In the Indira Gandhi Canal command area, grasslands and pastures should be developed for an integrated development of animal husbandry with agriculture.

For rainfed areas watershed approach has been accepted by the state. All watershed works should be developed as an integrated programme under proper guidelines and funding provision. The agriculture development and land developments are looked after by different Agriculture and Rural Development departments in the state. At grassroots level there is hardly any organic nature of integration. As a result crop productivity and production has suffered. The agricultural extension system dear not look to land and moisture conservation measures on the foundation of which a successful crop raising is possible.

The state Government has a very good opportunity to take advantage of new initiatives taken by the Government of India to increase the pace of development in agriculture sector to attain 4 per cent growth rate. The two main schemes are RKVY and ATMA. The state has already demarcated 10 agro-climatic zones and these can form basis for proper planning as per resource base and area needs. All schemes can be converged under DAP so there will be no duplication of efforts and funds. This will also take care of land, water and vegetation development in a coordinated manner under the state specific policies. This will, however, need a political will to see the interest of farmer and fragile ecosystem of the state.

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