REVIEW OF LITERATURE
CHAPTER 2

REVIEW OF LITERATURE

A proper understanding of the problem demands the analysis of the existing body of knowledge in the area of research proposed. Hence, in this chapter an attempt has been made to present the relevant aspects of the problem including the related studies which have a bearing on this investigation. The available literature has been presented under the following heads.

2.1. Trends in cotton area, production and productivity
2.2. Factors influencing adoption of crop production technologies
   2.2.1 Adoption of sustainable agriculture/eco-friendly practices
   2.2.2 Relationship between independent variables and adoption agricultural practices
2.3. Sustainable agriculture
   2.3.1 Concepts
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   2.3.4 Influencing factors
   2.3.5 Practices
   2.3.6 Attitude
   2.3.7 Knowledge
   2.3.8 Adoption
2.4. Technology transfer process and systems approach to agriculture
2.5. Information Management pattern of farm scientists, extension personnel and farmers.
2.6. Constraints perceived by farm scientists, extension personnel and farmers
   2.6.1 Farm scientists
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   2.6.3 Farmers
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2.1 TRENDS IN COTTON AREA, PRODUCTION AND PRODUCTIVITY

Although cotton is grown in about 70 countries, nearly 85 per cent of the world production is contributed by eight countries, namely China, USA, India, Former USSR, Mexico, Turkey, Pakistan and Brazil. India constitutes around 23 per cent of total cotton area of the world, but only 11 per cent of total world production. The world average yield of cotton was around 579 kg per hectare in 1996-97 as against 317 kg in India.

World cotton area ranged from 30,000 to 35,550 million hectares, with an annual average of around 32,819 million hectares during the period from 1970-71 to 1996-97. The lowest area under cotton was covered in 1975-76 and the highest area in 1995-96. World cotton production ranged between 11.706 million metric tones and 20.700 million metric tons during the above period. The lowest production of 11.706 million metric tons was recorded in 1975-76 and the highest of 20.700 million metric tons in 1991-92 with an average annual world production of 15.808 million metric tons. World cotton production has been increasing with an average productivity of 481 kg ranging from 369 kg to 597 Kg. per hectare during the above period. The highest yield of 597 Kg was recorded in 1991-92 and the lowest yield of 369 Kg per hectare in 1970-71 (ICAC, 1997).

Production in the Indian Union was only about 2.3 million bales in 1947-48, which rose to 15.5 million bales in 1996-97. India ranks only third in production although it has the largest area under cotton in the world, estimated at around 8 million hectares. The production has increased

In terms of productivity similar upward trend was noticed from 88 Kg in 1947-48 to 317 kg lint/ha during 1996-97. The yield was below 100 kg in 1950's, it improved to about 100 Kg in 1960's, above 150 kg in 1970's, above 200 kg in late 1980's and 250 to 300 kg lint/ha in 1990's. The yield level in India was low against 550 kg in Pakistan and 1500 kg in Israel, the world average being 481 kg per hectare. (Bhale, 1990; ICAC, 1997)

The major causes for decline in production and productivity were attributed to high degree of fluctuations in rainfall, varying soil types, depth of soil and soil moisture, non-availability of adequate certified seeds, non-adoption of improved production technologies such as line sowing, lack of water management practices, use of low seed rate and inadequate fertiliser and non-adoption of pre-monsoon sowings etc. Excessive use of insecticides and non-availability of separate extension staff for transfer of technology work were also reported to hinder the productivity. Besides research gaps like non-availability of short duration, high yielding hybrids for irrigated areas drought tolerant and pest and disease resistant varieties/hybrids, non-perfection of integrated nutrient management and plant protection measures for cotton ecosystems and unorganised marketing system for realising attractive prices by the farmers were considered to limit the production and productivity. (Basu, 1989)

2.2 FACTORS INFLUENCING ADOPTION OF CROP PRODUCTION TECHNOLOGIES


In contrast non-significant relationship was observed by Vijayaraghavan (1977) with small and marginal farmers, Palaniswamy (1978) with Malligai (Jasminum sambac) and Mullai (Jasminum ahuclatum) growers, Srinivasan (1981) with dry land farmers, Balasubramanian (1985) with puise growers and Selvakumar (1988) with cotton growers.

Occupational status: Negative and significant relationship between occupation and adoption was reported by Somasundaram (1976) and Vijayaraghavan (1977) with small farmers, Salunka (1976) in respect of the beneficiaries and non-beneficiaries of SFDA, Manivannan (1980) with sunflower growers, Palani (1987) with paddy farmers. Occupational status was found to have positive and significant relationship by Jeyakrishnan (1984) with the adoption of low cost technology, Balasubramanian (1985) with puise growing farmers and Sekar (1994) with groundnut growers.

On the other hand Balu (1980) observed non-significant relationship with groundnut growers.


Nature of family: Chandrasekaran (1979) and Ravichandran (1980) found positive significant relationship between nature of family and adoption behaviours of sugarcane growers whereas Sekar (1994) reported otherwise in the case of groundnut growers. Similarly Sharma (1974) reported non-significant relationship with marginal and non-marginal farmers and Thyagarajan (1979) with adoption of agricultural innovations.

Nature of house: Krishnamoorthy (1984) reported non-significant relationship between nature of house and adoption with small, medium and big dryland farmers.


Annual income: Raju (1969) pointed out that the farmers with high income were in a position to take more risk and face uncertainty in a better way than farmers with low income. Positive and significant relationship between annual income and extent of adoption was reported by Garg et al. (1978) with small farmers, Palaniswamy (1978) with Malligai (Jasminum sambac) growers, Ravichandran (1980), Sekar (1992) with sugarcane growers and Sekar (1994) with groundnut growers.

Whereas Viswanathan (1972) and Sharma (1974) observed a non-significant relationship with small farmers and Venkatapirabu (1988) with sugarcane farmers.

Farm power: Palaniswamy (1978) observed a negative non-significant relationship between farm power and adoption behaviour of Mullat (Jasminum auriculatum) growers. On the other hand Palaniswamy (1978) reported positive and significant relationship between farm power and adoption with Malligai (Jasminum sambac) growers, Rajapandi (1983) with wetland and garden land farmers and Sekar (1994) with groundnut growers.


Perception of attributes of innovations: Better perception of attributes of innovations influenced the adoption as reported by Lakshmanan (1987) and Sekar (1994) in respect of improved groundnut technologies.

Sharma and Nair (1974) and Baskaram and Praveena (1982) however reported that non-profitability was the major reason for non-adoption of improved cotton practices and dryland practices respectively.


On the other hand Baskaram and Praveena (1982), Bhoite and Nikalje (1983) and Rajagopalan (1986) found that lack of technical knowledge as the main reason for non-adoption.

Family influence: It is often claimed that the decision a farmer takes regarding the adoption of improved varieties and technologies are not of his own always, but a joint action of his family members on many occasions. Subramanyan (1981) also reported a positive and significant relationship between innovativeness and family influence. Sekar (1994) reported a positive and significant relationship between adoption and family influence.

Community influence: Man as a social being neither live apart from others nor is he independent of their influence being members of a community. There is few decision he could make in the community without regard for others directly or indirectly. Other members of the community serve as a referent or influential in his decision to adopt new practice. Subramanyan (1981) and Sekar (1994) reported a positive and significant relationship between the farmers' innovativeness and their perception of the relevancy of the selected farm practices to the norms of their community.

Input availability: Knight and Lakshmanan (1976) reported that non-availability of the sulphuric acid closer to the village in the required quantity at the time of sowing was the reason for non-adoption of acid delinting of cotton seeds. Similar findings on input non-availability were reported by Arokoyo (1982) and Rajagopalan (1986) with paddy technology, Jeyakrishnan (1984) with low cost technology, Krishnamoorthy (1984) with respect to dryland technology, Subramanian (1987) with respect to use of Azospirillum by millet growers and Sekar (1992) with sugarcane production technologies.

Financial situation: Poor financial condition coupled with difficulty in availing credit from various sources at the time of cultivation was one of the major constraints in the adoption of improved crop production technologies as reported by Programme Evaluation Organisation (1969) in respect of high yielding varieties of rice and Jowar, Athsan and Hoque (1977) with rice technology, Asaithambi (1981) with groundnut technology, Balasubramanian (1981) with improved cowpea variety, Baskaram and Praveena (1982) with dryland agricultural practices and Singh (1983) with improved sugarcane technologies.

Socio-economic consequences: Desai et al., (1970) made a study on the impact of improved seed and irrigation technology of groundnut on rural employment in Sourashtra district. The study indicated that the farmers using improved variety of groundnut utilised 50 per cent more labourers than the farmers who used local variety under irrigated condition. The proportion of hired labour
hours to the total labour hours was more in improved variety farms compared to the local variety farms,

Singh and Sahay (1972) analysing the impact of high yielding variety programme in Kosi area found that farmers got increased per acre yield of paddy and wheat, and they shifted to more profitable marketing agencies and opted to government sponsored credit institution from traditional ones, purchased more household goods and items of comfort and luxury from their profits.

Parameswaran (1973) reported that the major impact of cotton package programme on the farmers of Tamil Nadu was increased yield and income followed by purchase of power and hand operated sprayers (61.0%), motor and pumpsets (45.0%), deepening of wells (31.0%) levelling and bring new lands under cultivation (7.5%) and digging new wells (5.0%).

Somasundaram (1976) reported that there was an increase in yield, income and outside contact among the adopter small farmers as a result of adoption of I.R.20 paddy. He further reported that there was a change in the farm and home living and institutional participation as indirect consequences of adoption.

Marothia (1977) observed increase in yield, net return and total cost per hectare in advanced farming compared to traditional one. In advanced farming 33.0 per cent more man-days per hectare on groundnut were observed than in traditional farming.

Chandrasekaran (1979) reported that the registered sugarcane growers purchased farm implements, land, invested their earnings in other business and government bonds, cleared their debts as a result of adoption of improved sugarcane production technologies.

Balasubramanian (1980) reported that due to the adoption of improved rice technology the average yield of rice had doubled in both progressive and non-progressive settings. He also found a remarkable shift from informal sources to formal sources of credit among rice farmers. Farmers in both the settings invested their income for the purchase of draught and milch animals followed by other items. Farmers in progressive setting had pronounced comparatively more change in material possession than in less progressive setting.

2.2.1 Adoption of sustainable agriculture/eco-friendly practices: Ervin and Ervin (1982) in the conceptual model indicated that physical, personal, economic and sociological factors explaining the adoption behaviour of farmers, They found that education of farmers and erosion potential were significant at conventional levels, whereas less experienced farmers were more inclined to accept the merits of conservation practices and adopt number of practices by farmers.

Kunnal et al. (1984) reported that 46 per cent of farmers had adopted soil and moisture conservation measures such as contour bunding, deep ploughing and surface collection of water in black cotton soil areas of Bijapur.

Rahim and Wallace (1984) found that adoption of reduced tillage technology is positively associated with maize average yield and additional farming experience tend to increase adoption of soil conservation practices.

Venugopal (1985) observed that more than 60 per cent of participant farmers in ' Dryland Agricultural Project ' had fully adopted ploughing across the slope, land smoothing and levelling and opening of dead furrows at 10 feet interval in Chintamani taluk of Kolar district.
Comboni and Napier (1987) found that the theoretical perspective had some utility for predicting adoption of farming practices. The best predictors of use of conservation programme were farm structure factors. Psychological variables also explained the use behaviour of farmers.

Reddy (1987) found that the adoption level of big farmers significantly higher than that of small farmers in respect of soil and water conservation practices and improved dry farming and dryland ragi cultivation practices. According to him adoption behaviour of farmers had positive and highly significant relationship with education, farm size, economic status, social participation, mass media participation, extension participation, risk orientation and economic motivation.

Singh and Sharma (1989) while reviewing the progress of various operational research projects in the country have concluded that adoption of various soil and moisture conservation measures per se have provided 20-25 per cent increase in crop yield.

Snehalatha (1991) reported that Azospirillum seed treatment, which was one of the new technologies, diffused maximum adoption level (55.00%). However, Krishna et al. (1996) found that specific technologies like green manuring, crop rotation and agro-forestry were more adopted than IPM and bio-fertiliser technologies.

Kutty (1996) reported that the dependent variable adoption of sustainable agricultural practices was positively and significantly influenced by independent variables such as farming experience, income from agriculture, exposure to interpersonal sources, perception on available sustainable agricultural techniques and extension contact.

### 2.2.2 Relationship between Independent Variables and Adoption of Agricultural Practices

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It could be inferred that progressive farmers with larger farm size, better mass media exposure, higher economic motivation, more extension orientation and better perception were likely to help for better adoption of agricultural practices. Better information proneness and higher annual income also enhance adoption.

2.3 SUSTAINABLE AGRICULTURE

2.3.1 Concepts: The term sustainable agriculture is a recent origin although the science and practice are as old as the origin of agriculture. Many scientists have earlier attempted to define the concept and postulate measures to put this concept into practice (Altieri, 1987; Edwards, 1987; Anonymous, 1989, 1990, 1991a, 1991b, 1993a and 1993b; Tisdell, 1988; Ainsworth, 1989; Madden, 1989; Francis and Youngberg, 1990, Reagonold er ai., 1990; Rodale, 1990; Singh et ai., 1990; Schaller, 1990; Allen et ai., 1991; Conway et ai., 1991; Hess, 1991; Jodha, 1991; Chopra, 1993; Jones, 1993; Campbell, 1994). Since than the concept has been undergoing changed in idea and mode of operationalisation.

Granatstein (1988) had summarised the historical development of the concept of sustainable agriculture. According to him, earlier, this concept was conceived as “organic farming”, a term which was originally coined by Rodale in 1940s. Other term such as "natural", "ecological", "biological", "alternative", "low-input" and "regenerative" have been used in contrast to "high-input", "maximum production" and "intensive" agriculture.

Weil (1988) defined sustainable agriculture as an agricultural programme, policy, or practice contributes to agricultural sustainability if it: "(1) enhance or maintain, the number, quality and long term economic viability of farming and other agricultural business opportunities in a community or region, (2) enhances, rather than diminishes, the integrity, diversity, and long-term productivity both the managed agricultural ecosystems and the surrounding natural ecosystems and (3) enhances, rather than threatens, the health, safety, and aesthetic satisfaction of agricultural produces and consumers alike."

Incorporating various aspects, FAO (1989) defined sustainable development as "Management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of
human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically and socially acceptable”.

The Technical Advisory Committee of the Consultative group on International Agricultural Research (1989) stated that “sustainable agriculture is the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of environment conserving natural resources.”

Ruttan (1989) proposed that research on sustainability should include “(a) the development of technology and practices that maintain and/or enhance the quality of land and water resources and (b) the improvement in plants and animals and the advances in production practices that will facilitate the substitution of biological technology for chemical technology.”

“A sustainable agriculture is one that, over a long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fibre needs; is economically viable and enhances the quality of life for farmers and society as a whole” (Anonymous, 1989).

According to environmental economists sustainable economic development involved maximising the net benefit under optimal level of interaction between biological, economic and social systems (Barbier, 1989).

Ecologist, resource scientist and biologist referred sustainable development as the ability to maintain productivity at field, farm or nation levels against stress or shock (Barbier and Conway, 1990).

Many environmentalists suggested that sustainable development should be based on minimum resource use and to prevent environmental degradation to improve the quality of life (Rees, 1990; Redclift, 1987).

Abrol and Katyal (1990) opined that in simplistic terms, sustainable agriculture implied endurance of productivity level through certain agricultural practices over a period of time.

Ray (1990) reported that the sustainable/low-input agriculture had two criteria that this agriculture should lower costs (thus presumably improve farm profits) and reduce negative impacts on soil and water resources. Thus, three broad areas of concern that seem to underline the concept of viable, both in the short term and long term perspective, be dynamic and adaptable to changing needs and give priority attention to the renewable natural resource base.

Rodale (1990) opined that sustainable agriculture striven for integrated use of a wide range of pest, nutrient, soil and water management technologies at farm level to give strategy specific to the bio-physical and socio-economic conditions. Sustainable agriculture aimed for an increased diversity of enterprises within farms, combined with increased linkages and flows between them. By-products or wastes from one component or enterprise would become inputs to another. Thus natural processes might increasingly substitute for external inputs.

It was generalised that a sustainable agriculture package for each area will have to be developed jointly with the total community since practices, which are not socially compatible, will not.
be acceptable. This is where the social engineering aspects of technology development and dissemination require attention (Anonymous, 1991a).

John and George (1991) pointed out that a sustainable agricultural system must be economically and ecologically sound, economically viable with social justice among sectors as society.

Venkataramani (1991) defined sustainable agriculture as that farm or farming which produces sufficient food to meet the needs of the present generation without eroding the ecological assets and the productivity of the life supporting system of future generation.

Young (1992) postulated that sustainable development and growth underline "3 Es" such as economic theory focusing on economic efficiency and resource rights, ecological theory involving ecosystem functioning and maintenance of environmental integrity and equity theory on distributional pattern.

The economists' views of sustainable development embraced economic growth in the level of real GNP per capita, then sustainable economic growth not impaired from bio-physical impacts and economic development (FAO/AFP, 1992).

While appraising projects, human cost/benefit analysis and environmental cost were to be considered (Summers, 1992).

The development of sustainable agro-ecosystems was viewed as the trade-off between productivity, stability, sustainability and equitability. In otherwords increasing productivity by moving to monoculture system, mechanisation and use of other inputs was considered at the expense of sustainability (Young and Burton, 1992)

Goodland et al., (1992) defined the basic operational principles of sustainability through Output Rule: Waste emissions from a project should be within the assimilative capacity of the local environment to observe without unacceptable degradation of its future waste adsorptive capacity or other important services and Input Rule: (a) Renewable: Harvest rates of renewable resources input should be within regenerative capacity of the natural system that generates them. (b) Non-renewable: depletion rates of non-renewable resource inputs should be equal to the rate at which sustained income or renewable substitutes or developed by human invention and investment. Part of the proceeds from liquidating non-renewable should be allocated to research in pursuit of sustainable substitutes.

Commission of European Communities (1992) stated that tomorrow's environment depends on how we act today; the word sustainable is intended to reflect a policy and strategy for continued economic and social development without detriment to the environment as all human activities are dependent on the carrying capacity of the ecosystem.

Thomas and Rick (1993) quoted that the narrow focus on the production function on the inputs of land, labour, capital and management and the use of on-farm profitability as the primary definition of sustainability.

Lawrence (1994) redefined the concept as a holistic system achieved through rural resource use characterised by resilience of resource base, conservation of resource base, equity of resource access, integration into existing social organisation, enhanced innovative capacity of farmers and constant increased productivity.
Roling, (1994) emphasised the need for motivation of large number of farming households for co-ordinated resource management to make the sustainable agriculture as operational. For instance pest and predator management, nutrient management, controlling the contamination of aquifers and surface watercourses, livestock management, conservation of soil and water resources, seed stock management, ete, need collective decisions to such resources.

Pretty (1996) defined sustainable agriculture as a system of production persuing through incorporation of natural process such as nutrient cycling, nitrogen fixation, conservation of parasites and predators, reduction in the use of off-farm external and non-renewable inputs damaging the environment or harming the health of farmers and consumers targeting to minimise variable costs. His concept further embraced equitable access to productive resources of humane, greater use of biological and genetic potential of plant and animal species. Local knowledge and practices not fully explained by scientists, self-reliance among farmers and rural people, greater match between cropping patterns, productive potential and environmental constraints of climate and landscape were to be ensured for long term sustainability of production levels with emphasis on integrated farm management and conservation of soil, water, energy and biological resources.

As the above definitions did not expressly address the idea for a trade-off the needs of the present and future generations, FAO (1995) tried to improve the concept by including the following criteria for Sustainable Agriculture and Rural Development (SARD):

"Meeting the basic nutritional requirements of present and future generations, qualitatively and quantitatively while providing a number of other agricultural products, providing durable employment, sufficient income, and decent living and working conditions for all those engaged in agricultural production, Maintaining and, wherever, possible enhancing the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the socio-cultural attributes of rural communities, or causing contamination of the environment, reducing the vulnerability of the agricultural sector to adverse natural and socio-economic factors and other risks, and strengthening self-reliance."

FAO (1995) while reviewing the working rules for SARD singled out three important rules for operational purpose such as equity among all sections of society, resilience or capacity of the system to withstand external disturbance and efficiency in the use of resources.

Pretty (1996) identified six types of local group or institutions such as community organisations, natural resource management, farmers research, farmer-to-farmer extension, credit management and consumer groups which were directly relevant to the needs for a sustainable agriculture.

2.3.2 Dimensions/components: Sustainability of soils, food self-sufficiency and profitability on stable basis were reported to be the three primary dimensions of sustainability (Douglas, 1984; Edwards, 1987).

Ehrenfeld (1987) expressed that sustainable agriculture should resist anything that tends to separate farmers from their lands. Keenay (1989) felt that environmental soundness, profitability, productivity and maintenance of social fabric of rural community as the primary concern of sustainable agriculture.
Sound environmental management, conservation of natural resource base and attainment and continued satisfaction of human needs with different characteristics such as stability in pest tolerance, regeneration capacity, productivity and profitability, resiliency to external stress, appropriateness to the needs and skills, self-reliance for inputs and non-disruptiveness of social system (Anonymous, 1990). Greater reliance on information and lesser reliance on chemicals and energy inputs were referred as characteristics of sustainable agriculture (Bunch, 1990). Francis (1990) was of the opinion that sustainable agriculture was represented by organic farming to realize maximum economic yields.

Francis and Youngberg (1990) were of the view that sustainable agriculture systems are indicated by reduced ecological degradation, stable productivity, economic viability, stable rural communities and quality of life.

The workshop on sustainable agriculture comprising farming professionals and organized by ILEIA came out with five important criteria such as productivity, security, continuity, identity and adaptability (Anonymous, 1991b).

Conway et al. (1991) believed that sustainability should necessarily exhibit less specialization and less dependency on outside inputs.

Floquet (1991) reported that major criteria on which farmers made their decisions were food supply, cash income and input productivity.

Mackay (1991) considered that system diversity as an important indicator.

Swaminathan (1991a) proposed ecologically secure, economically efficient and socially equitable options as indicators. This Sustainable Living Security Index (SLSI) was claimed to be the legitimate indicator of Sustainable Development of Agriculture (SDA) because of its intimate linkage with welfare goals like poverty alleviation meeting basic needs, human development and quality of life.

Goodland et al., (1992) identified certain direct criteria and indicators of sustainability such as: population stability, greenhouse gases, acidification, toxic substances, soil degradation, aquifers, natural ecosystems and species extinction.

They also mentioned on indirect statistical indicators of long run sustainability like energy intensity, renewable energy proportions, material intensity, recycled proportions, transport intensity, water use, crop land cultivated and pastoral use.

Dunlop et al., (1992) in their studies identified nine dimensions viz., protect and enhance soil, ensure supply of safe and whole food, improve site specific knowledge of farmers, enhance environment and wild life habitat, increased diversity, improved farm economy, reduced agro-chemical use, reduced energy use and reduced purchase of inputs as most important in explaining the concept of sustainable agriculture.

Harrington (1992) interpreted sustainability and sustainable agricultural development in terms of agro-ecology, equity and sustainable growth. Further, he elaborated agro-ecology as system resilience, efficiency of inputs and recycling of nutrients as important indicators. Equity interpretation embraced inter-generation equity and the rights of non-human species and sustainable
growth focusing on continued growth in productivity, while maintaining the quality of resources devoted to agriculture.

Izac et al., (1992) pointed out that sustainable agriculture contained three equally important components namely environmental quality and ecological soundness, plant and animal productivity and socio-economic liability indicating the quality of life and profitability for farmers, farm workers and rural communities.

Reijntjies et al., (1992) stated that agriculture would be sustainable, if it was ecologically sound, economically viable, socially just, humane and adaptable. Productivity (output per unit of land and input used) security (minimising risk of production), continuity (maintaining soil and water health) and identity (self-respect, social justness and humanness) as some of the indicators.

A joint review report indicated four broad interacting factors of environmental, economical, human and technological dimensions for sustainability (WRI/UNEP/UNDP, 1992).

Garforth (1993) observed that a sustainable farming system depended on availability of inputs that did not damage the physical environment.

Jones (1993) opined that any concept of agricultural sustainability must accommodate the dynamic interaction, positive and negative, between agricultural activities, environment and society.

The narrow focus of the production function on the inputs of land, labour, capital and management and the use of on farm profitability as the primary definition of sustainability nad come under severe attack from sustainable agriculturists, who argued that the social and environmental consequences of production were as important as the economic outcome (Lyson and Welsh, 1993).

Nadkami (1993) mentioned productivity (yield or net income), stability of yield or net income and sustainability of yield and net income and equity in terms of income distribution as operational indicators of sustainable development.

Pookpakdi (1993) opined that a sustainable production system should be directed towards three essential goals namely food security, employment and income generation and natural resource conservation and environment protection.

Saleth (1993) in his studies concluded that the critical dimensions of sustainable development in general and Sustainable Development of Agriculture (SDA) in particular were ecology, economics and intra/inter generational equity.

Van den Ben (1993) was of the view that indigenous knowledge and competence that enabled farmers to depend upon their own ability to take decisions as a precondition for effective operation of sustainable agriculture.

Gale and Cordray (1994) identified nine measures of sustainability in terms of quantity produced, social system persistence, ecosystem health, price and supply fit of local products, global ecosystem diversity, ecosystem integrity with external inputs, resistance to ecological crises, insurance and natural evolution.

Mendoza (1994) expressed that any agricultural system to be identified as sustainable one must achieve objectives like increased productivity, profitability and economic wellbeing of farmers,
preservation of environmental quality, self sufficiency for food, equitable distribution of economic returns and optimal utilisation of internal resources produced on farm.

Walter and Reimer (1994) used Delphi technique to arrive at dimensions of sustainability and classified these under agrarian/structural and environmental/ ecological. Under agrarian/structural aspects three pairs of dimensions viz., centralisation - decentralisation, dependence - independence, competition - community were included. Under environmental/ecological aspects, domination-harmony with nature, specialisation-diversity and exploitation restraint were identified.

2.3.3 Measurement: Many authors have attempted to explain and measure sustainability through relevant indicators appropriate to the situations to understand the direction in which the agricultural developments is in progress.

Khosla (1987) characterised sustainable development designed with factors like resource conserving, equitable, economically efficient, waste reducing, socially compatible, employment generating, self-reliant and need fulfilling.

Häilu (1988) opined that the sustainability of food production systems involves both environmental and socio-economic dimensions. He also suggested an ideal sustainable system that could maintain or enhance environmental quality and remain robust against external stress or major disturbances, satisfy society's future demands for food and fibre and assure the economic and social well being of producer.

Lynam and Herdt (1988) proposed that sustainable growth perspective can be operationalised and measured at plot level by looking at the changes in yields and total factor productivity explained in terms of changes in the level of inputs, technical changes and changes in resource quality.

The Index of Sustainable Economic Welfare (ISEW) developed by Daily and Cobb (1989) had taken into account average consumption, its distribution across social groups and the long-term deterioration in environmental assets like soil, water, air, and ozone.

Swaminathan (1989) opined that prevention of soil erosion, conservation and management of water resources, conservation of biological diversity using in-situ, ex-situ, in-vitro and in-vivo methods and promoting the spread and development of economically viable and ecologically sound farm techniques as the main components of sustainable agricultural systems.

Brklacich (1989) identified the elements of a sustainable production system as food sufficiency dimension, resource stewardship dimension and producer community dimension.

Lal and Miller (1990) pointed out that some of the manipulable components for attaining sustainability were: improved cultivars and cropping systems, tillage and crop residue management, application of fertilisers and organic amendments and water management. Ray (1990) enlisted some more means to achieve greater sustainability involving biological diversity, crop rotations, animal integration, the soil as biological system, knowledge-based farming, human scale farm size and minimal dependence on non-renewable resources. Khosla and Sunil (1991) reported that the combination of agro-forestry, crop husbandry and animal husbandry enterprises had important environmental benefits such as reduction of pressure on forests, efficient recycling of nutrients, reduction in nutrient leaching and soil erosion, improved of micro-climate.
Agarwal and Sunita (1991) expressed the view that under the existing levels of population pressure, high levels of productivity could only be sustained through disciplined management of the common and fair distribution of their benefits.

International Institute of Tropical Agriculture (1992) reported that the sustainability of a cropping system was according to the resources involving either biological, physical or socio-economic factors and the degree to which a given resource was subject to degradation, determined the sustainability of the system.

Thomas and Rick (1993) found that increase in expenditures for equipment and machinery, prevalence of corporate farms, higher rates of tenancy and the prevalence of large farms were associated with lower levels of diversity at the country level. Conversely, higher levels of diversity are found in countries with greater farm labour expenses, where more medium size farms with farmers likely to farm full time.

Saleth (1993) in the process of arriving at Sustainable Living Standard Index (SLSI) illustrated the index in working out sustainability status of agro-climatic zones of India. The SLSI was a composite of Ecological Security Index (Proportion of per cent forest cover and net sown area), Economic Efficiency Index (indicated by land productivity and area under cereals) and Social Equality Index (indicators were people above the poverty line and female literacy). The SLSI of a household at a given point of time was also measured in terms of income status, asset ownership status, food and nutritional status and educational status (Anonymous, 1992 and 1993b).

Lawrence (1994) proposed three dimensions for sustainable agriculture as ecological, economic and social indicators.

Shrivastava (1994) suggested the strategies for sustainable development like suitable alternatives beneficial to the ecology of the area through soil and water conservation, increased productivity, improved quality of life and checking environmental crisis.

An agricultural behaviour index was constructed from measures of pesticide use, sources of nitrogenous fertiliser, farm diversity and whether or not people grow a home garden to represent the practice of alternative agriculture (Beus and Dunlop, 1994) Stockle et ai. (1994) Proposed a framework for evaluating the relative sustainability of a farming system using nine attributes like profitability, productivity, soil quality, water quality, air quality, energy efficiency, fish and wildlife habitat, quality of life and social acceptance. They recommended scoring based on quantifiable constraints within each attribute. They also suggested for other evaluation techniques like expert opinion and computer simulation models for those, which are not amenable to direct measurement.

Kutty (1996) pinpointed six important dimensions like resource use efficiency, environmental soundness, economic viability, technological appropriability, economic feasibility and local adaptability for sustainable agriculture.

2.3.4 Influencing factors: Fitzsimmons and Manning (1961) reported that financial security was inversely related to family size and positively related to ability to attain goals.

Neil and Rogers (1963) observed that achievement motivation is significantly related with measures of management of farm.
Hendee et al., (1969) opined that education was strongly associated with environmental concern and the same was endorsed by Buttel and Finn (1974).

National Wild Life Foundation (1969) observed that age and environmental concern were inversely related.

Roth and Sanders (1984) found that adoption of technological packages and constraints in adoption were associated with farm resources and goals along with technical constraints.

Kalliyanpur (1984) reported that farm size and productivity were inversely related. Same results were obtained by Shilaja (1990).

The population explosion by the year 2000 AD in Sahelian and Sundanian Zones of West Africa was reported to adversely influence the carrying capacity under traditional rainfed production systems (World Bank, 1985).

Rao (1985) found a positive and significant correlation between farming performance and farmers education level, land holding, innovativeness and achievement motivation.

Bora and Ray (1986) revealed that return on investment was significantly correlated with farm size, cropping intensity, innovation proneness, farming experience, economic motivation and level of aspiration.

Increased contact with the researchers and extension technicians had provided the farmers a better information source exposure in the development of strategies to improve their farm holdings (Lancini, 1987).

Gowda (1988) reported that there was significant relationship between socio-economic status of watershed farmers and their annual farm income but not with farm productivity.

Malia and Korsching (1989) observed that there was no evidence of differences between conventional and organic operations with respect to size tenure, age or education levels of the producer.

Nagaraja (1989) reported that management efficiency of sericulturists significantly influenced their economic performance which were influenced by land holding, rearing intensity, education, experience, economic motivation, level of aspiration, innovation proneness, self reliance, scientific orientation, achievement motivation and contact with extension agency.

Robert and John (1990) while explaining the reason for institutional constraints to productivity gains in the Sabel (West Africa) mentioned that the problems of inadequate input delivery systems, poor functioning of commodity marketing systems, farm gate commodity prices, etc. impeded the adoption and diffusion of sustainable technology.

Shilaja (1990) found a positive and significant relation of education, extension contact, extension participation, economic motivation, achievement motivation and innovation proneness of farm women with their farm productivity while it was reverse in decision making.
Agarwal and Sunita (1991) while explaining the need of community participation reported that most of the village environment except for livestock and crop lands demanded management of common property resources by all.

Gowda (1991) revealed a positive and significant relationship between crisis management of farms and their prior exposure to crisis, farming intensity, farm size, attitude towards farming systems and achievement motivation.

Dunlop et al., (1992) reported that aged, smaller and less educated farmers were having significantly broader view of sustainability than younger, larger and graduate farmers.

Lyson and Weish (1993) reported that, increased level of local control and decision making would influence the diversification of farm activities enhancing the farming sustainability. They also found that a shift from conventional farming patterns towards sustainable farming patterns had increased local control and decision-making on farms.

Hesterman and Thorburn (1994) reported that creating sustainable options for farming systems in USA required addressing both technical and non-technical barriers reflecting on economic, informational and attitudinal barriers.

Rogers (1996) opined that the impact of unfavourable attitude of the farmer for whom the land held by him was an adversary, or a taskmaster that kept him in slavery, would result in the degradation of creation.

Saltiel et al., (1994) revealed a strong influence of diversified crop-livestock operations, considerations to future plan, perceived long range profitability, favourable attitude towards alternative agriculture and access to information from professionals and farm trade journals on adoption of low input sustainable agriculture (LiSA) practices.

Gowda (1996) in his profile analysis of rice farmers found that family education, family size, farm size, socio-economic status, farming intensity, achievement motivation, economic motivation, level of aspiration, linkages with extension and research systems were the differentiating characteristics. Age, farming experience, family education, farm size, decision marking pattern, socio-economic status, achievement motivation, attitude towards sustainable farming, innovativeness, farming commitment, value orientation, extension system and research system linkages had positive significant relationship with sustainability of rice farming, whereas, farming intensity and economic motivation were found to possess negative but significant relationship.

Nagabhushanam (1997) studied the attitude towards sustainable agriculture; knowledge and adoption level of eco-friendly practices by the farmers in the watershed environment of Karnataka State. He found that the farmers were of mediocre level in respect of the independent variable viz., age, educational status, land holding, farming experience, decision making level, annual income, participation in water shed programme, mass media status, communication status, social participation, socio-economic status, risk orientation, innovativeness and perception on eco-friendly practices. While studying these among marginal, small and big farmer categories, they were found to be significantly differing in majority of their characteristics. More than half of the respondents were found in medium sustainability group. Further he found that among different categories of farmers, there was significant difference in the performance of indicators like crop diversity, ecosystem management, soil environment level and carrying capacity. In general the land productivity,
enterprise-supporting ability, integrated pest management, crop diversity, social equity and crop productivity were found to contribute significantly to sustainability. The variables like land holding, participation in watershed programme, socio-economic status and training undergone were found to have significant relationship with their sustainability level.

Further he observed that variables like extension participation of marginal farmers, participation in water shed programme, extension participation and risk orientation of small farmers and educational status, socio-economic status and training undergone by big farmers had significant relationship with sustainability. He also inferred that majority of the respondents had favourable attitude towards sustainable agriculture. Besides variables like educational status, communication status, social participation, risk orientation of small farmers and communication status, risk orientation and land holding of big farmers had exhibited significant relationship with their attitude towards sustainable agriculture. While studying the influential factors, he observed that the variables like communication status and risk orientation were found to be highly significant in predicting the variation in knowledge level of farmers on eco-friendly practices. The characteristics like communication status, extension participation and risk orientation of marginal farmers and small farmers and educational status, participation in water shed programme, risk orientation and perception on eco-friendly practices of big farmers had significant contribution in predicting the variation in knowledge level of farmers on eco-friendly practices. The variables like communication status, extension participation and training undergone by marginal farmers, participation in water shed programme, risk orientation and innovativeness of small farmers and socio-economic status, training undergone, economic motivation and perception of eco-friendly practices of big farmers were found to influence the adoption of eco-friendly practices by these farmers.

2.3.5 Practices: Sustainability of agriculture development requires real transfer of decision-making power and innovative ability among farmer. Although research system have evolved many simple to complex technologies to sustain agricultural development, the socio-economic and cultural background of farmers are figured in many situations. Out of the available technologies, very few are being utilised in the real situation. Dover and Talbot (1987) opined that no single agricultural method has a corner on sustainability. Any farming system whether chemical intensive or natural can be in some aspects resource-conserving and in other aspects wasteful, environmentally unsound or polluting. Simply substituting non-chemical alternatives may not necessarily make agriculture more sustainable.

In USA, rising costs of conventional agriculture and biological resource degradation prompted farmers to show interest in low-input sustainable agriculture. In the investigation, it was shown that soil erosion was reduced from 18 to 1 Mt/ha/year and pest control was accomplished without pesticides (Anonymous, 1988).

Stieme er ai., (1988J reported that traditional practices of Amish farmers who had been following socio-religious rules provided insights into biological control of insect pests and diseases, and nutrient cycling.

Schrimpf and Dziekan (1989) reported on the effectiveness of some botanical pesticides like castor oil, papaya leaf mixture, etc. They also found out that cowdung ash could be used for storing maize free of weevils.

Ray (1990) indicated that the concept of Integrated Pest Management (IPM) has a major role to play in enhancing agricultural sustainability, specifically with regard to insect pests, weeds and plant and animal diseases.
Eltiti and Ipach (1991) reported that when compared to conventional farming, low input farming showed a six fold higher number and biomass of earthworms and saprophytic and predatory nematodes.

Zanaboni (1991) found that forest relics and hedges might provide a key for restoring biological equilibrium in ecosystems disturbed by chemical inputs. Low input no-tillage agriculture generating ecological interactions similar to natural ecosystems, promoted agricultural production (House and Brusk, 1991).

The Institute for Low External Input Agriculture (ILEIA), on role of alternative farming methods had cited the practices such (a) crop rotation that mitigate weed, disease, insect and other pest problems, increase available soil nitrogen and reduce the need for purchased fertilisers and in conjunction with conservation tillage practices, reduce soil erosion, (b) integrated pest management that reduces the need for pesticides, (c) management systems to control weed and improve plant health, (d) soil and water conserving tillage and (e) animal production systems with stress on disease prevention as components of alternative agricultural systems (Anonymous, 1991b).

Baldwin (1991) referred to vermi composting as the process of using earthworms and microorganisms to convert organic waste such as manure or household refuses to valuable compost. Earthworms help the farmers by decomposing organic matter, generating nutrient rich erust and opening channels in the soil, thus improving soil fertility and structure.

Mollison (1992) viewed permaculture as a sustainable way of adapting to the rich resource base. Permaculture is partly about agriculture, partly about gardening, transport, architecture, finance, social design, non-waste production, waste-recycling etc. It is a design system for people and also for the rehabilitation of native species and damaged landscape of which agriculture is the main agent of damage.

Save and Sanghavi (1992) had portrayed about the natural farming. Here, step by step the farm was completely brought under organic farming with complete deletion of Chemicals. He used earthworms for tillage, tried and succeeded in trying out better and more beneficial spacing for coconuts etc. According to them for more than 30 years his farm had run profitably.

Sheila et ai., (1993) found that producers who scored in the ‘high’ group on the input change seale (the decreased use of agricultural Chemicals group) tended to farm significantly fewer aeres and had a significantly higher percentage of family income earned off the farm than those producers in the low group. Further they found that the majority of producers were used atleast some of the alternative practices in the production practices seale. Larger sized producers (on either the ICS or PPS) on any other attitudinal items or in involvement in organisations or purchasing pattern. Further, they found that very few significant differences were observed between the high and low sustainability groups on two scales. However, there were consistent trends within each seale.

Krishna et ai., (1996) found that majority of extension workers of University of Agricultural Sciences, Bangalore, Kamataka State department of agriculture and Non-Government Organisations (NGO) opined that green manure improved soil fertility and organic matter content.

In Taimil Nadu Elangovan and Vasanthakumar (1997) identified eco-friendly technologies like bio-fertiliser application, green manure, vermi compost, enriched farm yard manure, compost application, coimposed coir pith, neem cake application, IPM, seed treatment with Trichoderma,
afforestation, nitrogen fixing trees, seed kernel extract, agro-forestry, Integrated farming system and rice-fish-azolla culture for sustainable farming.

2.3.6. Attitude: Sheila et al., (1993) suggested to include structural factors like community and organisational involvement, or attitudes on sustainable farming while framing policies for the development of Pacific north west horticultural producers. They found that the general characteristics of surveyed farm size and producers varied widely. They further found that there was significant difference among the small and large farms with respect to number of practices. Roughly equal percentage of both small and large-scale producers were found to use less chemical fertilisers, herbicides and insecticides. Small scale producers were more likely than large-scale producers to use limited primary tillage and non-commercial sources of nitrogen. But, these smaller scale producers were less likely to practice rotation with legumes or green manure, cover crops, and field wind breaks for erosion control.

Kutty (1996) while analysing the factors responsible for attitude of farmers towards sustainable agriculture, found that exposure to interpersonal sources had significant positive relationship, whereas it was reverse on perception about availability of sustainable agricultural techniques and price of agricultural produce.

Krishna et al., (1996) found that majority of households irrespective of men and women, dry or irrigated in the Malnad and Maidan zones of Karnataka had favourable attitude towards environmental/ sustainable issues for the organisations and for the practice of agricultural extension.

2.3.7 Knowledge: Rogers (1983) generalised that the rate of awareness, knowledge for an innovation is more rapid than its rate of adoption. Shanmugasundaram (1987) found that 98.33 per cent of farmers were aware of the enriched Farm Yard Manure (FYM) technology. Alexander et al., (1989) reported that the level of knowledge about pest control was low. Only 41 per cent of the respondents knew the common pest attacking soybean crop. None of them knew the name of a pesticide or the dosage required for controlling the pest. According to Sophia (1991) among the dryland farmers more than 60 per cent of the farmers possessed good knowledge on the dryland practices viz., summer ploughing, seed rate, seed treatment, pre monsoon sowing of cotton, and cluster beans intercropping system, fertiliser application and chemical control of boil worms. Kutty (1996) observed that the independent variables like education, income from agriculture, exposure to interpersonal sources, perception about availability of sustainable agricultural techniques and extension contact contributed positively and significantly to the variation of knowledge about sustainable agriculture.

2.4 TECHNOLOGY TRANSFER PROCESS AND SYSTEMS APPROACH TO AGRICULTURE

2.4.1 Technology transfer process: The process of technology transfer consisted of four sets of basic activities involving research system to evolve technology, extension system to transfer the technology from research station to the clientele, client system which adopts the technology and takes benefit from it and support system for the technology transfer process by providing necessary inputs required for the use of technology and also by providing facilities for marketing the output (Jaiswal and Arya, 1979).

Reddy (1981) further improved the process of technology transfer system by including the components like input system, economic system, psycho-socio-cultural system and administrative and organisational system.
Singh (1981) reported three distinct systems like technology production, technology dissemination and technology utilisation systems. Here the research system takes care of technology production, its output becomes the input of the dissemination system, whose output becomes the input of the utilisation system and a process of feedback operates at all the levels. Similarly, Kumar (1981) had also mentioned the involvement of three systems such as research system, extension system and clientele system in the process of transfer of technology. According to Reddy (1982) the total process of technology transfer involved sub-process or phases like invention (production of technology), diffusion (dissemination of technology) and integration (adoptions and assimilation of technology) in a social system.

Different workers had also discussed effectiveness of major systems like research, extension and client in detail.

Research System: Singh (1973) pointed out that less than 20 per cent of the technology available to Indian farmers had only been adopted. In many instances, the innovations were not fully tested under diverse local conditions before they were released (Singh, 1974). Further Jaiswal and Arya (1979) reported that the researchers sometimes ignored the field problems and requirements. This was due to the lack of communication between the client system and the research scientists. Research Scientists were supposed to be aware of field problems through the feedback given by the client system directly or through extension agencies. However, the feedback on field problems to scientists had been extremely meagre. As a result, the improved technologies were not oriented to field conditions.

In the inland aquaculture modern practices were transferred to users by way of effective extension services through demonstration centres, rural aquacultural and operational research projects, advisory services, Lab-to-land programmes, self explanatory and illustrated pamphlets and organising training courses for various categories of field functionaries (Natarajan, 1980). In fresh water aquaculture research, great strides had also been made by the successful development of hatchery systems, increased quality seed production and by adopting different aquaculture systems for carps in the experimental farms and farmers' fields resulting in high production rates (Silas, 1983). Sen and Das (1986) reported that majority of the fish farmers perceived the technologies as moderately complex, divisible, relatively advantageous and compatible, although variation was observed between the states like West Bengal and Tamil Nadu, due to unfamiliarity of practices recommended, incongruent with existing level of professional experience, socio-cultural resistance for adopting certain practices, group management of ponds and lack of awareness about profitability.

Extension system: The effectiveness of extension system was often limited due to delayed and inadequate allocation of funds, inadequate and untimely supply of inputs, teaching aids not available on topics locally needed, lack of training in office management, spending over-time on writing reports and accounts, lack of training in extension methods and supply of audio-visual aids, lack of communication about the latest research findings and non-availability of books, bulletins, etc, as reported by Suryanarayanamoorthy (1965).

Several studies confirmed that the extent of promotional efforts made by the extension agency was directly related to the rate and extent of transfer of improved farm technology (Singh et al., 1970; Rogers and Shoemaker, 1971; Singh, 1972; Jaiswal and Arya, 1974; Perinbam, 1981; Kalaichelvan, 1984; Krishnamoorthi, 1984).
The studies further revealed that no single extension method or medium could be most effective under any given situation. It was always the exposure to the same idea through proper selection and use of combination of suitable media and methods in logical sequence, which increased the communication efficiency. (Hussain, 1971; Nanjaiyan, 1973; Mani, 1976; Singh and Singh, 1976; Sripal, 1978; Rajendran, 1980)

Reddy (1981) reported that the area of operation of extension personnel such as number of villages including the hamlets, total cultivation area, total geographical area, inaccessibility, number of households and the distance between block headquarters and village headquarters, etc, influenced the performance and effectiveness of extension personnel as it determined the frequency of contacts with the villagers and the intensity of their work.

Studies by Singh et al., (1976) and Chambers and Wickremanyake (1977) indicated that the workload of the extension workers was too heavy in terms of area allotted and physical accessibility and ultimately hampered their effectiveness in the transfer of technologies.

Benor and Harrison (1977) identified the following factors inhibiting the efficient transfer of farm technology in India: (i) lack of single line of command; (ii) dilution of efforts by assigning a multipurpose role to field extension workers; (iii) excessively large areas of operation; (iv) lack of regular training for updating knowledge of extension workers; (v) lack of proper ties with research; (vi) low status and morale of extension workers; and (vii) duplication of services by various agencies of development.

Jaiswal and Arya (1979) and Reddy (1982) in their in-depth analysis reported the following factors in extension system that adversely affected the transfer of technologies:

(i) inadequate field staff (more area of operation and physical inaccessibility);
(ii) inadequate linkage with the research system;
(iii) lack of an educational approach;
(iv) ineffective use of extension methods;
(v) inadequate knowledge of extension workers;
(vi) lack of client orientation and
(vii) administrative bottlenecks.

Perraton et al., (1983) reported that in a situation where everything was lacking (land, capital, suitable seeds, fertilisers, water, distribution and storage arrangements, markets etc.) in favour of farmers, an extension service, however well organised, could not work miracles. Conversely, where a combination of favourable factors already existed and only a catalyst was lacking, the extension service might have spectacular results. If the extension service suffered from weaknesses itself (lack of qualified staff, lack of the means of transport and of political support, etc.) then the impact of extension service would almost certainly be negligible.

Client system: Extension scientists have done a great deal of work on the differential adoption behaviour of the client system and the factors associated with adoption (Singh and Singh, 1970; Rogers and Shoemaker, 1971; Sharma and Nair, 1974; Shukla, 1980; Singh, 1981; Tyagi and Sohal, 1984).

The rate of adoption was reported to depend to a greater extent on the characteristics of the clients, perceived attributes of innovation, type of innovation-decision, communication channels,
extent of change agents and promotional efforts (Rogers and Shoemaker, 1971).

Caplan and Nelson (1973) reported the social system effect on the individuals and the diffusion of innovations. Similarly, Lee (1977) forcefully argued the system effect viewpoint by stating that understanding the social environment was important in understanding the behaviour of the individual. Kumar (1981) pointed out that the variable in the clientele system affecting transfer of technology operated at two levels, the individual farmer and the village or community. He has suggested that for efficient technology transfer, extension workers must understand the interactions between individual farmers and their social and occupational environment.

Reddy (1981) identified three types of factors viz., situational, personal and social in the client system having a bearing on the transfer of technology. He felt that effective transfer of a technology could be said to have been accomplished when the maximum number of potential adopters understood, accepted and actually practised the major part of an item of technology within a minimum time-lag and with the maximum benefits. The diffusion and adoption technology thus depended entirely upon the characteristics of individuals/groups for whom the technology had been meant for in addition to their perception about the attributes of the transferred technology (Lakshminarayanan, 1984).

2.4.2 Systems approach to agriculture: The effectiveness of agricultural technology transfer depended upon several interrelated factors. To understand this a system approach was necessary. Such an approach helps to identify essential linkages within and among research system, extension system and client system (Sekar, 1994).

The systems approach to agriculture in India though existed from the formation of the development departments, its analysis as a research was considered in late sixties. The systems in agriculture were identified as developing or innovative system, disseminating system and user system (Coughenour, 1968)

Guba (1968) while analysing the gap between the knowledge, production and utilisation concluded that the gap could be spanned either by the producer or by the utiliser or even the two acting in a concert; the researchers and the practitioners or clients represent two separate social system, each defined and identified by its own set of norms, values, languages and communication. Singh and Kumar (1973) conceptualised these systems as knowledge, production, dissemination and utilisation systems. While analysing the communication pattern in transfer of innovation, both horizontal and vertical problems involving three systems viz., research system, extension system and client system were considered by Ambastha (1974) and Balasubramanian (1976). Three basic activities were reported to be involved in the transfer of technology, namely production, utilisation and mechanism to link them through dissemination/communication/extension (Singh, 1981). Venugopalan (1989) also confirmed the existence of three systems namely research system, extension system and farmers' system in the transfer of dryland technology.

2.5 INFORMATION MANAGEMENT PATTERN OF FARM SCIENTISTS, EXTENSION PERSONNEL AND FARMERS

2.5.1 Farm scientists: Information management pattern of farm scientists included three dimensions viz., information input, information processing and information output pattern, which had been studied by many extension scientists.
Information input: Scientists got research ideas through referring abstracts, bibliography, catalogues and literature (Arnon, 1968; Channegowda, 1982), informal communication (Crane, 1970), scientific journals (Crane, 1970; Channegowda, 1982; Prakash, 1987), personal sources (Rogers and Shoemaker, 1971), field days and demonstrations (Rao, 1972), scientific experiments, seminars and workshops (Ganorkar, 1979), researchers from inside and outside state, farmers and extension personnel (Akinbode, 1981) and colleagues and immediate supervisors (Prakash, 1987). Besides, the information source by the different categories of the farm scientists revealed that the specialists had utilised professional meetings, extension personnel and farmers, whereas assistant specialists had adhered to professional meeting, immediate supervisors and farmers as reported by Ambastha and Singh (1977). Junior scientists were provided information through immediate technical supervisors and discussion with local progressive farmers while the senior scientists through professional meetings as stated by Prakash (1987).

Information processing: Scientists explored the farm problems by discussion with fellow scientists, referring literature, conducting experiments, discussion with local farmers and extension personnel, conducting field survey and by testing the local applicability of new farm practices (Ambastha, 1974; Balasubramanian, 1976; Ambastha and Singh, 1977; Dudhani, 1980; Thittai, 1981).

Information obtained from different sources were evaluated by the scientists in the light of past experience, considering the technical feasibility, discussion with experts and extension personnel (Ambastha and Singh, 1977; Balasubramanian, 1976), by conducting experiments (Chamala, 1979; Dudhani, 1980), demonstration in the village on the basis of existing agro-climatic conditions (Prakash, 1987) and discussion with policy makers and administrators (Akinbode, 1981).

The evaluated information were stored by maintaining special notebook (Balasubramanian, 1976), subject wise files and reference cards (Ambastha and Singh, 1977) and by collecting printed literature, maintaining common notebook and memorising (Prakash, 1987).

The transformation methods adopted by scientists were simple package of practices (Rao, 1972), pamphlets and leaflets (Dudhani, 1980), research reports, research articles, popular articles, radio talk, lecture notes and charts and graphs (Prakash, 1987). The category wise analysis revealed that the lower cadre had concentrated on publication of research and popular articles, whereas the higher cadre focused on extension activities as stated by Rockett and Smith (1982).

Information output: Farm scientists transfer the farm technologies by using individual contact methods like farm and home visits, office call by farmers and extension personnel and advisory letters to farmers; group contact methods like farmers training, group discussion meetings, demonstrations, seminars and training of extension workers and mass contact methods like publishing articles, organising field days, farmers fairs, organising exhibitions, distribution of leaflets and folders, writing for newspaper, audio-visual aids and radio talks (Sanoria and Singh, 1978; Chamala, 1979; Ganorkar, 1979; Dudhani, 1980; Channegowda, 1982; Rockett and Smith, 1982; Prakash, 1987; Singh, 1965; Sekar, 1994). Individuals occupying the central position in an organisation would pass on more information to extension workers and farmers (Singh, 1965; Sekar, 1994). Lionberger and Chang (1970) found that the training meetings were most frequently used method by scientists for disseminating the farm information. Thittai (1981) reported that the research findings were mainly disseminated through publication in local and international journals and annual reports. It may be seen from the previous studies that the information management pattern through input, processing and output of the farm scientists were generally adequate,
however refined specific information on location specific problems are needed for developing sustainable technologies.

2.5.2 Extension personnel: The information management pattern of extension personnel included three dimensions viz., information input, information processing and information output pattern, which had also been studied by many extension scientists.

Information input: Information regarding the technological package were obtained by the extension personnel through extension specialists (Rogers, 1960; Balasubramanian, 1976; Reddy, 1976), experimental bulletins, direct contact with experimental stations and discussion with scientists (Rogers, 1960; Ambastha and Singh, 1978), farm magazines, extension publications and professional meetings (Akhouri, 1973; Sanoria and Singh, 1976), official sources, pamphlets and folders (Ray, 1975), booklets, leaflets, radio, magazines and newspapers (Reddy, 1976) and superior officers and seminars (Sanoria and Singh, 1976; Sekar, 1994).

Regarding the information sources utilised by the different categories of extension personnel, (Patel, 1967) reported that the sources utilised by village level workers were block level specialists, training schools, farm magazines, specialists and research workers. The other sources utilised by them were agricultural extension officers, subject matter specialists, radio and newspaper (Reddy, 1976; Reddy and Singh, 1977; Sekar, 1994), Perinbam (1981) reported that the village extension workers obtained information through subject matter specialists of department of agriculture, leaflets and pamphlets. The level of utilisation of findings published by government, private and farm universities were found to be high, medium and low for agricultural officers, rural welfare officers and assistant agricultural officers respectively (Nagarajan, 1982).

Information processing: The information received by the extension personnel had been evaluated on the basis of their past experience (Akhouri, 1973), discussion with progressive farmers, specialists (Akhouri, 1973; Reddy, 1976; Sanoria and Singh, 1976), assessing the feasibility of the messages and discussion with colleagues (Balasubramanian, 1976 and Reddy, 1976) and discussion with higher-ups and conducting demonstrations in the farmer's fields (Sanoria and Singh, 1976; Sekar, 1994).

The evaluated information was stored by the extension personnel by means of memorising and noting down in a common notebook (Akhouri, 1973; Sanoria and Singh, 1976; Nagarajan, 1982), and by maintaining subject wise files (Balasubramanian, 1976; Reddy, 1976; Ambastha and Singh, 1976; Rakuman, 1983; Sekar, 1994).

Regarding transformation methods adopted by the extension personnel, Balasubramanian (1976), Ambastha and Singh (1978) and Sekar (1994) reported that the extension personnel transformed the messages in the form of success stories, new stories, lecture notes, leaflets, cyclostyled materials, charts and other visuals. Apart from these methods, usage of circular letters, leaflets, posters, slogans and radio talks were the other methods utilised by the extension personnel.

Regarding the information processing observed by the different categories of extension personnel, Nagarajan (1982) reported that the major evaluation methods followed by agricultural officers, assistant agricultural officers and rural welfare officers were considering the economic and local feasibility of the information and weighing in the light of past experience. He also indicated that the foremost information storage method used by agricultural officers was memorising, whereas assistant agricultural officers and rural welfare officers stored the information by making note in a
common notebook. Agricultural officers transformed the stored information into lecture notes in popular language, but the assistant agricultural officers and rural welfare officers transformed the messages into circular letters and cyclostyled materials.

Rakuman (1983) and Sekar (1994) found that the village extension personnel evaluated the information mainly by discussion with progressive farmers and higher-ups in the department. The block level extension personnel evaluated the information based on their experience. He also found that the divisional and district level extension personnel evaluated by weighing in the light of past experience, discussion with fellow workers and cross checking it against past recommendations. He also found that majority of the village and block level extension personnel stored the evaluated information by making note in a common notebook. Most of the divisional and district level extension personnel stored the information mainly by maintaining subject wise files. Extension personnel at various levels transformed the stored information into simple package of practices, leaflets and success stories.

Information output: For disseminating of crop production technologies, the extension personnel were used to make farm and home visits (Khara, 1967; Nagoke, 1967; Patel, 1967; Williams, 1971; Akhouri, 1973; Ambastha, 1974; Sanoria, 1976; Rakuman, 1983), personal contact and group discussion (Hiranand and Jain, 1967), office calls, training lectures, printed literature, field days, educational tour, demonstrations, radio talks, film shows and newspaper (Sanoria, 1976; Sekar, 1994) leaflets and folders (Balasubramanian, 1976), posters (Somasundaram, 1976) and campaign and meetings (Rakuman, 1983).

The farm and home visit was the most utilised channel by village level workers (Bhaskaran, 1970; Reddy and Singh, 1977; Ambastha and Singh, 1978; Perinbam, 1981; Nagarajan, 1982). Dudhani (1980) reported that gramasevaks had utilised individual contact methods like farm and home visits and office calls. Demonstration method stood first among the communication channels utilised by the village level workers (Bhaskaran, 1970; Reddy and Singh 1977; Ambastha and Singh 1978; Perinbam 1981; Nagarajan, 1982). Group meetings, training camps, educational tours were the group contact methods utilised by the village level workers (Bhaskaran, 1970; Reddy and Singh 1977; Ambastha and Singh, 1978; Sekar, 1994). Nagarajan (1982) had stated that the agricultural officers utilised farm and home visits and demonstration for the transmission of technical knowledge to the farming community.

Field days, farmers’ training, meetings and film shows were the popular methods adopted by the district level extension personnel (Ambastha and Singh, 1978). They also found that the State and range level extension personnel had utilised farm magazines, farm broadcast and circular letters.

The information management pattern in respect of extension personnel particularly at grass root level workers does not seem to be adequate to promote sustainable technologies. Besides they are to be trained on sustainable cotton farming methods suited to each agro-ecosystem so as to impart precision farming to the clientele.

2.5.3 Farmers: The information input and processing pattern of farmers are presented below:

Information input pattern: Three information channels such as personal-localite, personal-cosmopolite and impersonal-cosmopolite sources were generally utilised by the farmers (Sekar, 1994). The personal-localite channels such as fellow farmers, neighbours, friends and relatives,
progressive farmers, family members were reported to be the different sources of information utilised by the farmers (Viswanathan, 1972; Ernest 1973; Ramamurthy, 1973; Kalamegam, 1975; Balasubramanian, 1976; Ranganathan, 1976; Vellaichamy, 1979; Perinbam, 1981; Channegowda and Jalihal, 1984; Angadi, 1986; Velumani, 1988; Iqbal, 1992; Sekar, 1994).

Regarding the personal - cosmopolite channels, the farmers had used demonstration plot (Danda, 1972; Darbarilal, 1972; Vellaichamy, 1979), training programmes (Darbarilal, 1972), scientists and office calls (Ranganathan, 1976; Somasundaram, 1976; Iqbal, 1992), and extension personnel like assistant agricultural officers, agricultural officers and assistant director of agriculture (Iqbal, 1992; Sekar, 1994).

With respect to impersonal-cosmopolite sources, radio was the most credible source of information as was reported by Sekar (1994) and Supe (1971), Ramamurthy (1973), Singh and Prasad (1974), Vijayaragavan (1976) and Paneerselvam (1978). The other sources utilised by the farmers were exhibitions and posters, campaigns (Kalamegam, 1975; Vijayaragavan, 1976) and agricultural film shows (Agarwal and Kulkarni, 1976).

Information processing pattern: The received information was evaluated by considering profitability and witnessing demonstration plots (Ambastha, 1974; Balasubramanian, 1976; Vijayaragavan, 1976), discussion with progressive farmers (Ambastha, 1974; Vellaichamy, 1979), conducting trials (Ambastha, 1974), discussion with friends and neighbours (Balasubramanian, 1976), considering the availability of inputs (Vijayaragavan, 1976), discussion with family members (Vijayaragavan, 1976; Vellaichamy, 1979), discussion with officials of State department of agriculture (Pooviah, 1982; Vimala, 1989) and discussion with agricultural scientists (Arunachalam, 1991; Sekar, 1994).

The review also revealed that the major information storage methods followed by the farmers were memorising and making note in a common notebook in general.

Although it is claimed that the farmers are accessible to right kind of technology from right sources, the sustainable means of farming was hardly realised.

2.6. CONSTRAINTS PERCEIVED BY FARM SCIENTISTS, EXTENSION PERSONNEL AND FARMERS

Some studies on the problems perceived by the research, extension and client systems in the technology transfer process were briefly reviewed to understand at organisations and farm level problems.

2.6.1. Farm scientists: Sampson (1971) identified six problem areas like human relations, organisational structure, work methods, management practices, personal practices and union relations.

Several studies (Chandrakandan, 1973; Zaltman, 1973; Palaniswamy, 1978; Pathak and Mazumdar, 1981; Arulraj, 1984; Mohankumar, 1985; Balasubramaniam, 1988) reported that while developing innovations for adoption at field level the desired attributes such as profitability, compatibility, simplicity, trialability, communicability, credibility, technical appropriateness, perceived risk, feasibility, cost, durability, efficiency, immediacy of return and inputs availability could not be incorporated into an innovation and such innovations were not easier for transfer.
In the implementation of lab to land programme in West Bengal, Orissa, Andaman and Nicobar Islands, change agent constraints such as, weak directive from the head of the institute/department, lack of awareness on details of the programme, delay in release of fund, difficulty in procurement and distribution of critical inputs, irregular and untimely programme monitoring, weak reporting and passive accounting of the programme, lack of incentive to extension personnel, lack of vehicle and other facilities ete, were reported to have been faced by farm scientists (Ray era/., 1995).

2.6.2. Extension personnel: Venkataramana and Bhaskaram (1966) reported some barriers for extension work such as inadequacy of materials, equipment and literature needed for work, non-availability of supplies for demonstration, inadequate transport facilities and lack of sufficient audio-visual equipment. Too much office work, lack of appropriate training, recognition, incentives and opportunities for advancement to the village level workers were also reported to be other bottlenecks for effective extension work.

Kumar (1981) suggested that the effectiveness of the change agents could be improved by imparting interpersonal competence through training in human relations, team building, extension approach and methods to the extension personnel.

For effective agricultural extension work Benor et al., (1984) advocated to provide continuous staff training to extension staff and to reorganise the structural and functional system to make them accountable for the basic set of duties. Sen (1984) in his studies conducted in West Bengal suggested to provide motivation in change agent, suitable promotional avenues, in-service training and facility of higher studies. He added that attitudinal changes, decision-making, human relations and innovative management were the main areas to be improved.

Sigman and Swanson (1984) in their study on extension organisations in developing countries comprising Asia, Africa, Latin America, Caribbean and Oceania, ranked the problems of these countries as mobility, extension-training, equipment, organisational, technical training, teaching aids, linkage, technological and specific other problems, in their order of importance.

Vasanthakumar and Singh (1985) reported the following constraints expressed by extension personnel working in block level organisations: (1) inadequate staff, (ii) poor linkage among organisations, (iii) too much paper work, (iv) lack of incentives and (v) interference of influential.

Certain administrative constraints in technology transfer such as, political-bureaucratic patronage and top-down administrative system governing the rural/agricultural development resulting passive involvement of rural people, inadequate incentives to extension functionaries, lack of short-term and long-term training programmes for upgrading extension functionaries in their background and technical qualifications, indifferent attitude of the field level functionaries towards extension work, problems in staffing of the transfer of technology projects viz., non-availability of trained staff, delay in the recruitment of staff, frequent transfers and diversion of ill-equipped staff to the extension projects and lack of transport facility for the extension staff were also reported by Prasad et al. (1987)

Ogunfiditimi (1986) identified several problem variables acting as constraints to extension service viz., inadequate training, administrative bottleneck, confused state of being, immobility, credibility gap, poor remuneration and financing, communication gap, institutional within/between problems, relative value system, policy deficiencies, persistent instability, technological complexity
infrastructure inadequacies, relative poverty mitigation and inadequate coverage and bad timing. Out of these variables such as poor remuneration and financing, inadequate training, immobility and inadequate coverage given to certain innovations, and bad timing for its execution were found to contribute greatly limiting extension agents' performance with resultant negative effect on extension service in general.

In T & V system of Nepal, problems like lack of job security, promotion, transport, coordination, timely budget support, training aids, incentives, technical know-how, mobility and sufficient training were reported (Ray et al., 1995).

2.6.3. Farmers: Some studies relating to the constraints, which may impede farmers' adoption of improved technology, are reviewed in brief. These are presented under the sub-heads technological, economical and infrastructure constraints. These shall help in understanding the wide range of problems the farmers are facing and in selecting items for constraint analysis.

2.6.3.1 Technological constraints: Sharma and Nair (1974) stated that the important problems related to the cultivation of high yielding varieties, in order of importance were, high incidence of pests and diseases, lack of irrigation and high cost of inputs.

Tripathy (1977) reported that water management was the most important causal factor followed by disease and pest control and nitrogen application. The ecological factors like temperature, soil, rainfall and sunshine intensity together contributed to the extent of 20 per cent of the yield gap.

Sinna and Sinha (1980) found that lack of knowledge of improved methods of cultivation and lack of proper guidance were the important reasons for non-adoption of high yielding variety of maize.

Water management either directly or indirectly influenced most of the physical constraints encountered by farmers (Kahlon and Singh, 1981).

According to Reddy (1981) three types of factors in the client system were responsible in the adoption of new technology. The adverse climatic factors and unfavourable soil conditions discouraged farmers from the risk of adopting input-intensive and costly technology. Due to low diffusion of plant protection methods, farmers forego benefits of modern agricultural technology and endure heavy crop losses with new varieties. Lack of knowledge in fertilizer use is reported to be a problem in fertilizer use in crop production (Singh, 1981).

International Crop Research Institute for the Semi-Arid Tropics (ICRISAT, 1982) in the proceedings of the Regional Groundnut Workshop for Southern Africa identified the important constraints on groundnut production as shortage of seed of high yielding adapted cultivars, low plant population, weeds, diseases, pests, low produce prices and competition from other crops.

Some of the technological constraints identified by Chand (1984) in Nepal were - lack of knowledge about technology, more water requirement, lack of irrigation facility, irregular rainfall, inadequate field channel to deliver water to field, unequal opportunity to get water, non-control over the unwanted volume of water during monsoon, less water holding capacity of soil, lack of drainage facility, occurrence of flood, lack of equipment and improved implements, preference to other crops, non-adoption by neighbours, complicated process and lack of conviction.
Sen (1984) reported technological constraints on water management research and farm machinery. He suggested the need for research efforts to develop a crop technology appropriate to the physical environments of the region. He also pointed out that inadequate bullock power available to the small and marginal farmers had added to the need for improved farm tools and implements.

Ballav and Prasad (1985) were of the opinion that farmers’ knowledge about different innovations bore a negative relationship with the gap in technology. In other words, greater the technical know-how about an innovation, lesser the gap in that innovation.

2.6.3.2 Economic constraints: High initial cost on adoption of improved agricultural practices was reported to be one of the serious problems (Singh, 1961; Rai, 1967).

Radhey Shyam (1965) and Prasad (1967) observed that high cost and lack of money were the reasons, expressed by majority of non-adopters of fertiliser. It was further stated that 56 per cent of the non-adopters of improved implements did not adopt them due to poor drought animals. In another study Prasad (1967), Raheja and Singh (1981) reported that 42 per cent of the non-adopters of improved seeds did not adopt it due to high cost.

Higher cost of pesticide, herbicide and equipment, untimely supply of pesticides and small and fragmented holdings were stated to be the main reasons for non-adoption of pesticides and herbicides (Dubey, 1968).

Studies conducted by the Planning Research and Action Institute (PRAI, 1968) in Uttar Pradesh had revealed that the present stage of fragmentation rendered sound cultivation impossible and tended to make agriculture an uneconomic proposition. Further, small-scattered plots were generally unfit for introduction of improved agricultural technologies.

Nair (1969), Raheja and Singh (1981) and Singh (1981) found that high cost of fertiliser was the important problem of farmers. Sharma and Nair (1974) stated that the important problem related to the cultivation of high-yielding varieties was low price for the produce.

Singh (1974) stated that one of the reasons for rejections of farm technology was labour scarcity. Moreover, high labour wages made the cost of production high.

Bhilegaonkar (1976) reported that medium and small farmers perceived inadequate finance to match the cost of production as an important problem.

The steady rise in prices of production inputs could adversely affect the level of their use and productivity of agricultural commodities (Garg et al., 1976; Mishra et al., 1976; Singh et al., 1976).

Sinna and Sinha (1980) found that the most important reason for non-adoption of high yielding variety of maize was lack of money.

Kahlon and Singh (1981) stated that labour turnout to be a severe constraint to the adoption of intensive system of farming recommended by the research institutions, since the intensive labour used in experimental area was not available to most of the farmers to break the labour peaks.
Studies on gap analysis by ICRISAT (1982) revealed that capital was the most important single constraint contributing more than 50 per cent of the gap in terms of Rupees per hectare, particularly on smaller farms.

Sen (1984) stated that farmers had too little capital for investment and efficient use of their labour and inadequate facilities for development of skills. He also reported that the law of succession had contributed to continuous sub-division and fragmentation of holdings. The heavy, erratic and uneven seasonal pattern of rainfall created soil erosion problems, constraining agricultural development.

Waghmare and Waghmare (1985), in constraints analysis of labto land programme reported that high cost of fertiliser, lack of plant protection Chemicals and high cost of Chemicals, lack of regular number of irrigation, high labour wages, non-availability of labour in time were the main impediments in speedy transfer of wheat technology.

De and Bangarva (1986) stated that the technological gap was mainly because the production factors like fertilisers, herbicides and agro-chemicals were not only costly in relation to the return, but also because the technical know-how was still deficient on the part of the farmers.

Singh and Sharma (1986) reported that production inputs were beyond the reach of about 80 percent paddy growers in Kurukshetra district of Haryana State as the cost of these inputs were exorbitant.

2.6.3.3 Infrastructure constraints: Choudhury (1967), Rai (1967) and Jaiswal and Singh (1968) reported that lack of timely supply of production requisites to the farmers was a major obstacle to the adoption of improved agricultural practices. Prasad (1967) reported that 42 per cent of the non-adoption of improved seeds was due to inadequate and untimely supply of seeds. Gupta (1968) observed that among the non-adopters of Mexican wheat, 57 per cent of the farmers were such who did not adopt it due to lack of irrigation facilities. Radhey Shyam (1965) and Prasad (1967) also made similar observations. Nair (1969) found that untimely and inadequate supply of fertiliser was important problems of the farmers. Singh and Srivastava (1970) reported that the main problems of small cultivators were lack of irrigation facilities and uncertainty about the availability of irrigation water. Sharma and Nair (1974) also stated that the important problem related to the cultivation of high yielding varieties was untimely supply of fertiliser. Grewal and Singh (1975) observed that the marginal and small farmers were aware of the new technology of agricultural production but they needed adequate, assured and timely supply of crucial inputs to augment their agricultural production. Kamphol et al., (1977) in their studies concluded that inadequate fertiliser was the dominant constraint responsible for the wide yield gap between wet and dry seasons in Thailand.

Jaiswal and Arya (1981) indicated that the major problem of increasing the area covered by the high yielding varieties was due to lack of inputs, particularly seeds, fertiliser, irrigation, pesticides and transport facilities to the village. Transportation of inputs all the way to the village was also considered as a constraint.

Singh (1981) also found that non-availability of fertiliser was one of the important problems in fertiliser use.

Reddy (1981) stated that some Government policies on price structure of commodities acted as a hurdle for adoption of improved technology. The role of price incentive as a strong stimulus for
agricultural production had been well established, especially when pay off technology is available to promote investment by farmers.

Sagar (1983) concluded that fragmented land holdings, lack of soil testing facility were the important factors hindering productivity of crops. Sen (1984) observed that low use of modern inputs like high yielding varieties of seeds and fertiliser was largely due to short supply, substandard quality and poor delivery system besides demand constraint. Power supply was both inadequate and erratic. Use of inputs and on-farm investments had suffered due to inadequate flow of institutional credit. While studying the agricultural growth in eastern region of the country, he noted that investment in basic infrastructure like roads, transport, marketing, cold storage, rural godowns and processing facilities, etc., had been neglected.

Arya and Shah (1984) while identifying the main constraints on the adoption of technology found that due to high fragmentation and scattered holdings, farmers were not able to use human as well as bullock labours in moving from one location to another distant location and to exploit locally available water resources for irrigation purposes. Moreover, valuable lands were also wasted on boundaries.

Waghmare and Waghmare (1985) derived the constraints in transfer of technology as lack of standard agencies for quality seeds, their high cost and non-availability of finance in time.

Singh and Sharma (1986) stated that supplementary factors like electricity for running tubewells, diesel for engines and labour for farm operations were not only costly but also scarce. The traders had exploited marketing of their produce, and the farmers had not been provided with technical guidance to get rid of this exploitation.

The foregoing account is assembled from a variety of sources with a view to present a wide range of issues, opinions, research findings, approaches and tools influencing sustainability of farming.

2.7 CONCEPTUAL MODEL

A conceptual model is postulated based on the discussion and assumptions made in the theoretical orientation as well as the researcher's understanding of particular set of circumstances and of the simplification which he feels may be made to inherently complex relationship. The variables included in the study were classified under dependent and independent variables. The independent variables are the variables on the basis of which the prediction about the dependent variable is made.

The model (Fig. 1) indicates information generation by research system and dissemination of production technology to the clientele through extension system. In the present study 25 factors were considered as independent variables. The dependent variable sustainable cotton farming was measured through 14 indicators.
FIG. 1 CONCEPTUAL MODEL SHOWING THE ROUTE OF TRANSMISSION OF COTTON PRODUCTION TECHNOLOGIES AND THE RELATIONSHIP BETWEEN VARIABLES AND SUSTAINABLE COTTON FARMING