Informatics Blueprint for Integrated Water Resources Planning and Management at grassroots level: A Quintessential Requirement for Adaptation to Climate Change and Sustainable Agricultural Development in India

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Mission

Digital Opportunities (0s & 1s): A Powerful Engine for fostering Agricultural Growth, Poverty Reduction and Sustainable Resource Use in India

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1. Introduction

1.0 The search for socially desirable, economically viable, and ecologically sound pattern of resource use and ways of life, to promote sustainable development has been going on, ever since it's most popular exposition in the well known Brundtland Report entitled "**Our Common Future**" in 1987. In the field of development, "**good governance**" and "**local ownership**" have become important criteria for allocating natural resources, common property resources etc. "**Networking of People**": Academicians, Researchers, Planners, Decision Makers, Technocrats, Field Workers and NGOs, and "**Networking of Knowledge**" to understand any combination of related elements that work together to achieve a desired goal, **are essential** to facilitate "local ownership" and participate in "good governance".

1.1 Developing countries are facing a new threat "**eco-colonialism**" by the developed countries who insist on pre-implementation conditionalities (i.e. relating to environment) on irrigation projects (viz., dam projects), with a possibility of vested interest to dump their surplus food grains and other products, in the guise of protecting the environment (Menon, 2001)[1]. The UNDP's Human Development Report–2001 has introduced a **Technology Achievement Index (**TAI), which is an aggregation of four groups of indicators relating to : (a) the creation of technology (~**IPR Divide**), (b) diffusion of recent innovations (~ **Digital Divide**), (c) diffusion of innovations (~ **Extension Divide**), and (d) diffusion of human skills (~ **Education Divide**). Both national and international conferences have been discussing and deliberating on issues such as "**Sustainable Agricultural Development**, **Water Resources Development** and **Earth Care Policies**", "**Water & Food Security**", "**Water & Health and Sanitation**", "**Water and Natural Disaster**", "**Water Management & Decision Making**", "**Water & Ecology**", "**Water & Women**" and finally "**Water & Conflict**". According to our noted Scientist, Dr. M. S. Swaminathan (2001) [2], "bridging the expanding "Nutritional Divide" is fundamental to bridging the Divides" mentioned above.

[1] Menon, M.S (2001) : "Report of the World Commission on Dams : A Framework for Underdevelopment?", published in The Hindu, August 14, 2001

[2] Swaminathan M.S. (2002) : "Food Security and Community Grain banks", Yojana, January 2002

2. Water: A Resource which is ONE & INDIVISIBLE

2.0 Water, as a resource, is one and indivisible: rainfall, river waters, surface ponds and lakes and ground water are all part of one system. Water is part of a larger ecological system. Rivers and Underground Aquifers often cut across State boundaries. Floods and droughts affect vast areas of the country, transcending state boundaries. Out of 40 M.ha of the flood prone area in the country, on an average, floods affect an area of around 7.5 M.ha per year.

2.1 The basic source of water for both Surface Water (SW) and Ground Water (GW) is the same, namely **precipitation**. Precipitation, in the form of rainfall, occurs only for a few days in a year and varies from 100 mm in the Western parts of Rajasthan to over 10000 mm at Cherrapunji of Meghalaya. Hence, there is a need to conserve in the soil profile, aquifers, ponds, lakes, reservoirs and rivers, for use during the dry periods. It is estimated that 263 million people live in drought prone area covering 1/3rd of the country's total geographical area 0f 329 million hectare.

2.2 Growth process and the expansion of economic activities inevitably lead to increasing demands for water for diverse purposes: domestic, industrial, agricultural, hydro-power, thermal-power, navigation, recreation, etc. So far, the major consumptive use of water has been for irrigation. Agriculture is the greatest user of water, accounting for about 80% of all consumption. **About 70% of irrigation water is wasted in run-off or inefficient irrigation systems** (World Bank, 2003)[3]. Animal Husbandry Sector and Fisheries Sector also require abundant water. While Water is essential for sustenance of human life, it can as well create problems concerning "Human Health", being a carrier of vectors for diseases such as typhoid, cholera, diarrhoea, malaria, filariasis, shistosomiasis etc. if it is mismanaged (i.e. a warning indeed).

2.3 Water has an economic value in all its competing uses and there has been growing demand that Water should be recognised as an economic good. A major challenge today is to introduce economies in agricultural, municipal

[3] World Bank (2003): Concept Paper circulated in the "Multi-Stakeholder Regional Consultation for International Assessment on Role of Agricultural Science and Technology in Reducing Hunger, Improving Rural Livelihoods and Stimulating Environmentally Sustainable Economic Growth", 12-13 May 2003, New Delhi..

and industrial water use. In addition to this, availability of water is too highly uneven in both space and time. However, Water Scarcity is not a general phenomenon but is a regionally, locally, and seasonally specific problem. This can be substantiated through scientific and socio-economic analytical studies. Therefore, the Water Resource, which is a scarce and precious national and natural resource, should be **planned**, **developed**, **conserved** and **managed** as such, and on an integrated and environmentally sound basis, keeping in view the socio-economic aspects and needs of sub-national levels.

3. Water Resources Development Strategies: A Macro Analysis

(i) Physical Resources

3.0 The origin, distribution and utilisation of Water Resources of any country are profoundly influenced by its physiography, climate and soils. Physiographically, India is divided into the following regions: (a) the Northern Mountains, (b) the Great Plains, (c) the Central Highlands, (d) the Peninsular Plateau, (e) the East Coast belt, (f) the West Coast belt, and (g) the Islands. The Whole country has been further divided into **6** major River Resources Regions, **35** Basins, **112** Catchments, **550** Sub-Catchments, and **3237** (major) Watersheds. Efforts have also been undertaken to further delineate upto micro-watershed level, as it has been done in states like Tamilnadu.

3.1 Development of Water Resources, since our independence, has been undertaken for specific purposes like irrigation, flood control, hydro-power generation, drinking water supply, industrial and various miscellaneous uses. As a result, a large number of projects comprising dams, barrages, hydro-power structures, canal network etc., have come up all over the country in successive Five Year Plans. The irrigation potential created stands in the vicinity of 93 M.ha by 1999-2000 as against 22.6 M.ha in 1950-51 (pre-plan period).

3.2 Since bulk of rainfall occurs during a few days during monsoon, it is necessary to harness the water flow in the river by construction of large storage reservoirs. About 10 Million rainwater harvesting structures are to be constructed within a limited time period, to store the 400 BCM of river flows discharged into the sea without being utilised (Menon, 2001). This would involve acquisition of lakhs of hectares of land, **mostly from small**

landholders, displacing millions of poor farmers. With the failure of a monsoon (if occurs), these water bodies get dried up, resulting in crop failures, which will cause large-scale devastation and consequent hardship to people.

(ii) Water Use: Agricultural Production

3.2 In a span of five decades, food grain production, which was barely 51 M.Tons in 1950-51, crossed 208 M.Tons during 1999-2000. India is not only self-sufficient in meeting the food needs of the vastly increased population but also has built a buffer stock of over 50 M.Tons of food grains to tide over any shortages which may arise due to bad weather conditions (Mehta and Bandyopadhyay, 2002). India has become the second largest producer of Wheat, Rice and Sorghum, the third largest producer of Sugarcane, and the fourth largest producer of Cotton during 1995-97. In Fruits and Vegetable production, India shares first position with China. In the Animal Husbandry and Dairy Sector too, the progress has been very impressive with milk production increasing from 17 M.Tons in 1950-51 to over 75 M.Tons 2001-02.

3.3 As a consequence of Water Resources development works, apart from the major objectives, India has witnessed developments in **inland fish production too**. India has now the distinction of being **the seventh largest producer of fish** in the World and **second largest producer of inland fish** after China. Amongst the States, **the State of West Bengal** is the highest producer, followed by the State of Andhra Pradesh and the State of Bihar. It is evident from published statistics of the Government that these three States (Bihar, Andhra Pradesh and West Bengal), if put together, produce about 50 percent of total inland fish production in the country, while the State of West Bengal alone accounts for about one third of this production.

3.4 The country's population, which is over 1027 Million (2001 AD) at present, is expected to reach a level of around 1390 Million by 2025 AD. Consequently, the food grain production will, however, have to be raised to around 350 M.Tons by the year 2025 AD. This necessitates "development of Water Resources" to a substantial order, if the food and fiber needs of our growing population are to be met with. As per the published documents available, a broad assessment of the area that can be ultimately brought under irrigation, both by Surface Water (SW) and Ground Water (GW), has indicated that ultimate irrigation potential of the country would be of the

order of 139 M.ha under the categories viz. **Major, Medium and Minor**, as follows:-

- 58 M.Ha by Major and Medium Irrigation projects,
- 17 M.Ha by Minor Surface Water Schemes, and
- 64 M.Ha by Minor Ground Water Schemes.

3.5 It has been perceived that development of Minor Irrigation is quite advantageous, as this possess like small investments, labour intensive, quick maturing, and most of all, a farmer-friendly. Our noted Scientist, Dr. M. S. Swaminathan said, "We need more science, both in public and private sectors, related to agriculture, for falsifying the Neo-Malthusian predictions of widespread food and drinking water insecurity".

(iii) Water Use: Access, Equity and Equality Issues

3.6 Irrigation constitutes the main component of water use in rural areas. The Land Holdings of India are predominantly of small size. Marginal size holdings (< 1 Hectare) with an average size of 0.4 Hectare constitute 59%, Small holdings of 1 to 2 Hectare size constitute 19% of the total land holdings. Semi-medium holdings of 2 to 4 Hectare account for 13.2% and the rest are medium (7.2%) and large (1.6%). Increasing fragmentation of Land Holdings adversely affects crop production (Michael, 2002)[4].

3.7 The question of access, equity, and equality in Water Resources gets directly to the use of irrigation water. Has the expansion of irrigation benefited small farmers? Have the inter-class differences in irrigation widened or narrowed? What is the regional (State) distribution of irrigation by farm size? Deshpande et al (2002)[5] point out that the growth rate of all major sources of irrigation was found to be inversely related with the farm size in majority of the states between 1970-71 and 1990-91. Complex issues of equity and social justice in regard to water distribution are required to be addressed.

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[4] Michael, A.M (2002) : "Blue Revolution: A Step Towards Water Conservation & Management, Small Holder Irrigation, Drainage & Waste Water Usage, to achieve sustainable public health engineering and food security, and ushering in 2nd Green Revolution in India", presented as a Theme paper in the 2nd International Conference on "Sustainable Agriculture, Water Resources Development & Earth Care Policies" organised by Bhoovigyan Vikas Foundation (An Earth Care Foundation), New Delhi on 18-20 December 2002.

[5] Deshpande R.S, Venkatachalam L and Narayanamurthy A (2002): "Policies for Access, Equity and Equality : Physical resources and Human Resources", presented as a Theme paper in the 2nd International Conference on "Sustainable Agriculture, Water Resources Development & Earth Care Policies" organised by Bhoovigyan Vikas Foundation (An Earth Care Foundation), New Delhi on 18-20 December 2002..

4. PER CAPITA WATER AVAILABILITY: A SITUATION ANALYSIS

4.0 The Hashim Committee Report (1999) reveals that, against the annual precipitation of 4000 Billion Cubic Metres (BCM) occurring over the Indian landmass, the available run-off is estimated as 1953 BCM. The balance is lost to atmosphere by **immediate evaporation** and also to the ground as soil moisture. Out of this 1953 BCM, the utilisable flow is only 1086 BCM comprising 690 BCM of surface run-off and 396 BCM of replenishable ground water. While the ground water is being over-exploited, it is possible to harness only about 250 BCM of river flows through major, medium and minor storages, allowing the balance flow of more than 400 BCM (i.e. ~ 60% of the surface run-off) to be wasted to the sea every year. Such an enormous waste of this precious natural resource is going to have **a telling effect** on the lifestyle of the Indian people.

4.1 India faces an increasingly urgent situation: its finite and fragile water resources are stressed and depleting, while demand from various sectors ranging from agriculture to industry and also as a result of population growth, is growing rapidly. The Per Capita availability of fresh water is reducing due to increasing population and is assessed for different years are as under:-

Table-1: Per Capita Water Availability

Year	Population (In Million)	Per capita water availability (in Cubic Metres)
1951	361 M	5177
1955	395 M	4732
1991	846 M	2209
2001	1027 M	1820
2025	1394 M (projected)	1341
2050	1640 M (projected)	1140

(Source: Publications from the Ministry of Water Resources)

5. Drinking Water Supply (DWS) in India: Problems at the Grassroots

5.0 Rural water supply in India is the largest of its kind in the world and significant progress has been achieved due to sustained efforts by both the

Central and State Governments. Adequate drinking water (i.e. 40 litres per capita per day – lpcd) has been made available to about 90% of the habitations, as on 25th November 2002 (Table-2). This significant coverage is not with out any environmental costs. Heavy dependence on Ground Water (GW) for drinking water supply as well as irrigation coupled with inadequate recharging efforts, ineffective conjunctive use of water resources and the neglect of traditional practices and systems including rainwater harvesting have resulted in the depletion of Ground Water (GW) levels, which have fallen by more than 4 metres during 1981-2000 (i.e. 20 Centimetres per year).

5.1 The country is facing three major challenges in the water sector: (a) slippage of covered habitations, (b) water quality problems, and (c) sustainability of sources and systems (Meenakshisundaram, 2002)[6].

Table-2: Coverage of Rural habitations with DWF

Sl.No	Type of Coverage	Number of habitations	Percentage of Coverage
1.	Fully Covered	1,284,203	90.27
2.	Partially Covered	123,359	8.67
3.	Not Covered	15,102	1.06
	Total	1,422,664	

Despite improved coverage and access to drinking water supply (DWS) in rural India, about 217,211 habitations (as on 1st April 1999) were faced with water quality problems, as categorised below:-

Sl.No	Nature of Quality Problem	Number of Affected Habitations
1.	Excess Fluoride	36,988
2.	Excess Arsenic	3,553
3.	Excess Salinity	32,597
4.	Excess Iron	138,670
5.	Excess Nitrate	4,003
6.	Other Reasons	1,400

5.2 As adequate and reliable water quality data is not available, it has been very difficult to identify "hot spots" and optimally target limited resources. It has been reported that it was also not possible to carry out "risk assessment". Hence, interventions have been, in most cases, post-

[6] Meenakshisundaram S.S (2002): "Drinking Water Supply in India: A Strategic Policy Analysis", presented as a Theme Paper in the 2nd International Conference on Sustainable Agriculture, Water Resources Development and earth Care Policies", 18-20 December 2004, orgnaised by Bhoovigyan Vikas Foundation, New Delhi.

epidemic rather than preventive. Study Reports also reveal that Ground Water (GW) depletion has aggravated water quality problem (like excess fluoride, arsenic and brackishness), which has resulted in diseases like fluorosis and arsenical dermatitis.

5.3 Meenakshisundaram (2002) recommends that a survey / census of all drinking water sources requiring rejuvenation must be undertaken so as to facilitate drawing up an Action Plan for augmentation under the "SWAJALDHARA" mode remote sensing techniques can be used to identify the location of water bodies (Ponds, Lakes, Tanks etc). The DISNIC – PLAN Project for facilitating "**ICT in micro level planning**", sponsored by the Planning Commission during the Tenth Plan, could consider this suggestion.

6. Need for a Plan of Action to Protect, Allocate and Manage Judiciously

6.0 Fresh water, which was once viewed as infinitely renewable natural resources, is no longer available in plenty in India. Developing Countries are still to harness their water potential (Menon, 2001). Water distress is visible in desert and drought prone areas. Apart from the increasing mismatch in the supply-demand scenario, gross mismanagement of water resources, coupled with neglect of traditional water resources environment, have further aggravated the situation. The result is seen in the form of falling water levels, water scarcity, degradation of quality and prevalence of water-borne and water related diseases in several parts of the country.

6.1 In order to ensure the country against water stress and to create a greener India, the previous National Democratic Alliance (NDA) Government has announced its plan during the Year 2003 for "**interlinking of various rivers of India**". This programme has got the national attention, in view of its manifold objectives : (a) augmentation of irrigated agriculture (35 M.ha i.e. from 140 M.ha to 175 M.ha), (b) potable water for the rural and urban areas, and industrial water-supply, (c) generating cost-effective of hydropower (to the tune of 35,000 to 40,000 MW), (d) inland navigation, (e) ecological up-gradation due to minimum flow guarantee in rivers, (f) sizeable employment generation, (g) flood and drought mitigation, (h) increased tree farming and many other indirect benefits (http://riverlinks.nic.in).

6.2 The Common Minimum Programme of the United Progressive Alliance (UPA) Government talks about starting the project with the peninsular rivers (Gargi Parsai, 2004)[7]. The Common Public desire that the "interlinking of rivers" should become a "social and economic" programme of an equitable distribution of water for domestic and other purposes, with concerns on the issues of environment, ecology and displacement of people etc., rather than becoming a "political programme".

6.3 Water is rapidly becoming a scarce resource in India yet continues to be used inefficiently. If India's aspirations for continued economic growth and improved social and environmental conditions are to be met, then fundamental changes in how water is captured, allocated, planned and managed must occur. We need, therefore, need a plan of action for "**water accounting and budgeting**" at national, regional, sub-regional and grassroots level (i.e. village or block level) so as to protect, allocate and manage our available water most judiciously to ensure water security, food security, livelihood security, health security and ecological security for the People. This calls for an institutional set up for participatory Water Resource Management utilising the facilities available at the School of Earth Sciences, Colleges of Agriculture, Departments of Geography, School of Environment Sciences, and Centres for Water Resources Development Studies of Universities of India.

7. WATER QUALITY ISSUES: IS IT UNSOLVABLE?

7.0 Water Quality (WQ) is a function of chemical, physical, and biological characteristics and it impacts "use-of-water" or "ecosystems-within-the-water". Direct and indirect human activities (i.e. Land-use and agricultural practices) impact WQ problems in Water bodies (Viz. Rivers, lakes, aquifers etc). Even the "management action" to control point and nonpoint source pollution and treat wastewaters discharged into the environment, results in WQ problems.

[7] Gargi Parsai (2004): ""Interlinking of rivers: how, when and where" published in THE HINDU dated Tuesday, Oct 19, 2004

7.1 Studies carried out in India reveal that the most important causes of Ground Water Pollution are: (a) "**unplanned urban development without adequate attention to sewage and waste disposal**", (b) industrialization without provision of proper treatment and disposal wastes and affluent, (c) excessive application of fertilizers for agricultural development, and (d) over-irrigation intrusion due to excessive pumping of fresh water in coastal aquifers. This "over-exploitation" mainly accounts for seawater intrusion. Contamination enters Water bodies through one or more of the following ways:

- Direct point sources: Transfer of pollutants from municipal industrial liquid waste disposal sites and from municipal and household hazardous waste and refuse disposal sites.

- Diffuse agricultural sources: Wash off and soil erosion from agricultural lands carrying materials applied during agricultural use, mainly fertilisers, herbicides and pesticides.

- Diffuse urban sources: Run off from city streets, from horticultural, gardening and commercial activities in the urban environment and from industrial sites and storage areas.

7.2 Prevention and Control of Environmental Pollution (EP) has the required legislation support and review through the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs). Inland Water Quality gets monitored on 25 physico-chemical and biological parameters, through about 480 stations under Global Environment Monitoring System (GEMS) & Monitoring of Indian National Aquatic Resources (MINARS) programme. The National Water Quality Monitoring Network Programme covers about 126 rivers (including the tributaries), wells, lakes, creeks, ponds, tanks, drains and canals (http://envfor.nic.in). An "environmental information system (**ENVIS**)" is operational in the Ministry of Environment and Forests. Efforts should be made to undertake "**water quality monitoring**" at village level and the noticed quality be notified through Village Panchayat Raj Institutions. ENVIS should be enhanced to incorporate features of "localism" as well as "localization". The WQ is

"quality" in relation to some standards and the different "water use" have different standards.

7.3 In Water bodies, future water quality will be very dependent on future human activities, including **Water Management Policies**, and the direct effect of Climate Change may be very small in relative terms (Hanratty and Stefan, 1998).

8. Sustainable Development & Management of Water Resources: Water Bodies (Basin), Watershed, and Agro Ecology Region Planning - A Way Forward for grassroots level prosperity

8.0 Utilisable Ground Water (GW) potential of India is limited and is to be utilised judicially. Development and overexploitation of Ground Water (GW) Resources, in certain parts of the country, have raised the concern and need for judicious and scientific resource management and conservation. Presently, the ground water available at a place is considered as the property of the landowner. In many developed countries, the ownership of the land does not permit the land owner to utilise the GW indiscriminately.

8.1 Sustainable Development and Management of Water Resources (SW as well as GW) require a holistic approach (i.e. simultaneous attention to all aspects of Water Use and Management). This requires a thorough understanding of the hydrology of the SW System, GW System, Agro-eco Systems, Soil-Water-Plant-Environment interactions, existing and expected water demands, availability of energy for pumping and social dynamics.

8.2 The **Agenda-21** of the Rio Earth Summit (1992), the UN Convention to Combat Desertification (**CCD**), the UN Convention on Biological Diversity (**CBD**), the UN Framework Convention on Climate Change (**UNFCCC**) and its Kyoto Protocol, and the **Habitat Agenda** adopted by the UN Conference on Human Settlements in 1996, **directly or indirectly**, suggested **integrated planning and management** of Water, Land, Minerals, and Biota resources (that land comprises), for sustainable development and use at grassroots level.

8.3 The National Water Policy (1987) and the National Water Policy (2002) have addressed to the issues related to **develop, conserve, utilise** and **manage** Water Resources in this new millennium. The Hashim Committee

Report (1999) dealt with various issues related to "**Integrated Water Resources Development Plan**" in the Country and **warrants** timely action in respect of: (i) harnessing of the surface flows through major, medium and minor storages, (ii) improving water-use efficiency, and (iii) taking necessary steps for demand and supply. The Nagpur Declaration (2000)[8] on "Natural Resources Planning and Management for Sustainable Development" envisages that for integrated water resources planning and management, both "**river basins management**" at the macro level and "**watershed management**" at the micro level, should mutually complement each other. Long term planning needs a clear vision for Land & Water Resources Management at grassroots level.

8.4 The All India Soil & Land Use Survey (AISLUS) organisation has delineated the entire country **3237** major Watersheds (**6** major River Resources Regions, **35** Basins, **112** Catchments, **550** Sub-Catchments, and **3237** major Watersheds). Each Watershed contains a complex mixture of **soil types, landscapes, climatic regimes, land use characteristics,** and **agricultural systems**. Yet, this complexity is not unmanageable, and therefore can be subdivided into more than one Agro Ecological Regions (AER), on the basis of having **similar soil types**, **landscapes**, **climatic regimes**, **crop productivity** and **animal productivity**, and **hydrologic characteristics**.

8.5 Cropping Pattern of an area is determined by many factors, which include: **type of soil**, **climate**, **rainfall characteristics**, **farmer's requirements** of food grains for self-consumption as well as market supply, and **net rate of financial gain,** resulting in various alternative crops that can be grown in that area. Each State of the country is expected to concentrate on agricultural products most suited to its **agro-ecological** and **agro-climatic** conditions, as it is not possible to hope to be self-sufficient in all the essential commodities (Abdul Kalam and Rajan)[9].

8.6 AER Planning is useful in conjunction with Watershed Planning for developing a list of priority needs in monitoring, research, education, and implementation activities for various basins (water bodies) in the Country.

[8] National Association of Geographers India (NAGI)'s Annual Congress at Nagpur in January 2000.

[9] Abdul Kalam, A.P.J & Rajan,Y.S (1998) : "India –2020 : A Vision For The New Millennium – Food, Agriculture and Processing (Chapter-IV)", Viking Penguin Books India (P) Ltd, New Delhi, India.

Using the AER characteristics along with existing Water Quality Monitoring Information, it is possible to determine:-

- Where the steepest and most erosive landscapes are located,
- Where the water quality problems are most severe,
- Where land use patterns are most conducive to non-point source pollution production, and
- Where the research knowledge base concerning sources of pollution and methods of managing pollution is weakest.

8.7 Sustainability in Agricultural Development depends upon the judicious use of natural resources viz.: soil, water, livestock, plants, fisheries, forests, climate & rainfall, and topography. This requires that (a) both SW and GW supplies are maintained at the desired level, and (b) the quality of Land & Water Resources does not deteriorate with time.

8.8 For **each major Watershed**, it **is suggested** to engage **all stakeholders** within the Watershed, in discussions and coordinated planning efforts that cross state boundaries. In this connection, the following recommendations of the Core Group-V Report (2000)[10] on "**Agricultural Resources Information System (AgRIS)**", of the Standing Committee on Soils and Agriculture (Ministry of Agriculture) are noteworthy:-

- "A Decision Support System (DSS) on water allocation in an irrigation system to remove the existing disparities in the availability between the head-reach and tail-end farms and between large and small farms, to achieve "equity and social justice";
- "AER Planning is useful in conjunction with Watershed Planning for developing a list of priority needs in monitoring, research, education, and implementation activities for various basins (water bodies) in the Country".
- "A DSS on Water Bodies (Basin) using Watershed and AER Planning Concepts is to be taken up".
- "National Livestock Policy (NLP) Studies classifies the country into four livestock farming system viz., Cattle Farming System (CFS), Buffalo Farming System (BFS),

[10] Report of the Core Group – V on Agricultural Resources Information System, constituted under the Standing Committee on Agriculture and Soils of the PC-NNRMS, Department of Agriculture & cooperation and Department of Space, Government of India, 2000..

Sheep Farming System (SFS), and Goat farming System (GFS). To observe the possible linkage between livestock systems and cropping systems, demographic and agro-climatic features, DSS on Cattle Farming System (CFS), DSS on Buffalo Farming System (BFS), DSS on Sheep Farming System (SFS), and DSS on Goat farming System (GFS) may be developed".

9. Effective & Economical Management of Water Resources: Need for Frontiers of Knowledge through intensified Research Efforts

9.0 The National Water Policy (2002) envisaged that for effective and economical management of our Water Resources, the frontiers of knowledge need to be pushed forward in several directions by intensifying research efforts in various areas, including the following:

- hydrometeorology;
- snow and lake hydrology;
- surface and ground water hydrology;
- river morphology and hydraulics;
- assessment of water resources;
- water harvesting and ground water recharge;
- water quality;
- water conservation;
- evaporation and seepage losses;
- recycling and re-use;
- better water management practices and improvements in operational technology;
- crops and cropping systems;
- soils and material research;
- concrete, fiber reinforced concrete, new methodologies in tunneling technologies,
- instrumentation, advanced numerical analysis in structures and back analysis;
- seismology and seismic design of structures;
- the safety and longevity of water-related structures;
- economical designs for water resource projects;
- risk analysis and disaster management;
- use of remote sensing techniques in development and management;

- use of static ground water resource as a crisis management measure;
- sedimentation of reservoirs;
- use of sea water resources;
- prevention of salinity ingress;
- prevention of water logging and soil salinity;
- reclamation of water logged and saline lands;
- environmental impact;
- regional equity

9.1 With a view to devising a strategy for the future, it was learnt that the Central Ministry of Water Resources has commissioned a series of six reports on Water Resources Management (WRM) in 1990s, in collaboration with the Ministry of Urban Affairs, the Ministry of Rural Affairs, and the World Bank:-

- **Water Resource Management**: Initiating and Sustaining Water Sector Reforms
- **Inter-Sectoral Water Allocation, Planning and Management**
- **Groundwater Regulation and Management** – An Important Source of Drinking Water and Food Security
- **Irrigation and Drainage** in Indian Agriculture
- **Rural Water Supply and Sanitation**
- **Urban Water Supply and Sanitation**

The main feature which revolved around these reports included "**strengthening data**, **technological and information systems**". What will be **the role of Departments of Geography**, which are spread through out the country and educating more than 12000 students every year? Will they involve themselves in developing "**knowledge Information System and Management**" on Watersheds, as a part of "**ICT Diffusion Developmental Action Research**"?(Moni and Sundaram, 2003)[11] . **Geo-Informatics on DAMs (which is numbering about 4000) safety and relief measures at village level is a must** and can be developed through the Departments of Geography (200 in numbers) located through out the country.

[11] Moni. M and Sundaram K.V (2003): "Rainfed Agriculture: A Step towards Blue Revolution to usher in Sustainable Agriculture and Rural Development", Presented at the XXV Indian Geography Congress, held on 27-29 December 2003, Ghaziabad (Uttar Pradesh), India.

10. Integrated Watershed Development Approach (IWDA): A Holistic Approach for Sustainable Development of Rainfed Agriculture

10.0 Agricultural sector is the mainstay of the Indian rural economy around which, socio-economic privileges and deprivations revolve. Any change in its structure is likely to have a corresponding impact on the existing pattern of social equality at the grass-roots. The Indian Agriculture contributes about 25% of GDP, provides employment to about 65% of the labour force, and accounts for about 20 % of total exports.

(i) Critical situation of Agriculture

10.1 Agricultural development faces resource constraint for "**irrigation and drainage"** infrastructure, which continues to attract high public investment. It is quite relevant to note "the critical situation of Indian Agriculture", as appraised by the Planning Commission, during its Ninth Plan Mid-term appraisal, which was captured as follows :-

- Low public investment in irrigation and poor maintenance of rural infrastructure (specially canals and roads);
- Decline in investments in rural electrification, and in its availability. This has vastly affected production in eastern India, where huge Groundwater potential remains untapped;
- Rising level of subsidies for power, water, fertilisers, and food, which cut the public sector investments in Agriculture and also induce inefficient use of scarce resources (i.e. water)?
- Aggravation of environmental problems leading to loss of soil fertility and groundwater, which in turn **reduces** "return on capital", which leads the farmers demanding further subsidies to maintain the same level of production;

10.2 Most parts of Eastern Region (ER)[12] **lags** rest of India on some social indicators like: Poverty ratio (highest in Bihar), Infant fertility (highest in Orissa), Overall literacy (lowest in Bihar) and female literacy (lowest in

[12] The Eastern Region (ER) of India comprises of 130 districts covering states of Orissa, Bihar, Chhattisgarh, Jharkhand, Eastern UP, West Bengal and Andhra Pradesh.

Orissa and Bihar), and Poverty incidence varies within ER. In areas where investments in agricultural infrastructure have lagged, such as Bihar, Orissa, Assam and Madhya Pradesh, rates of growth in agricultural productivity and poverty reduction also lagged (Roy and Pal 2001)[13]. Given the strong linkage between output growth (particularly agricultural growth) and reduction in poverty, **accelerated agricultural growth is critical,** to reduce poverty in ER States. The **existing food security** has been achieved through "increase in irrigated agriculture" and "introduction of HYV of crops". Even then, the Rainfed Agriculture is crucial to the country's economy and food security because 67% of the net sown area is rainfed and about 44% of the total food production is contributed by the rainfed agriculture.

(ii) Farming without Irrigation: A hard way of Life

10.3 Rainfed agriculture is generally characterized by (a) low levels of productivity and low-input usage, (b) decrease of the agricultural intensification and (c) instability in production and the farmers' income. Small & Marginal Farmers (SMFs) in Rainfed areas, continue cultivating their land **in order to retain** their ownership (or user) rights. Rainfed Agriculture is hence complex, diverse and risk-prone. The Rainfed areas have not benefited from the "green revolution effects" of irrigated agriculture. Of this 67%, about 30% area is under dryland agriculture, wherein the annual rainfall is up to 400mm only. One-sixth area of the country is drought-prone.

10.4 Rainfall is erratic and poorly distributed in rainfed Areas, and soils are often severely eroded, infertile, and deficient in organic matter. It is true that "**the lesser the rain in an area, the greater the trouble for the farmers and villagers there".** A large number of farmers are Small and Marginal Farmers (SMFs) and depend on Rainfed agriculture for their livelihood. Farming without irrigation is a hard way of life (http://lnweb18.worldbank.org/sar/sa.nsf). At the same time, **they have an abundance of biomass and cattle-waste**. It is noteworthy that they have never used cattle-waste in the cultivation process. Adopting composting and discontinuing chemical based agricultural practices, has gained widespread visibility (http://www.geocities.com/ ncdc_vns/org-frm.htm).

[13] Roy, B. C. and Suresh Pal (2001) : Incremental Capital-Output Ratio in Indian Agriculture, Agricultural Economics Research Review, 14(1):34-46

(iii) Watershed: A Geo-Hydrological Unit for development of Rainfed farming

10.5 The agricultural investment in India has traditionally concentrated on the development of irrigable lands[14]. Agricultural policies have systematically discouraged small-scale rainfed farming (Gopal and Sashi Kumar, 1995)[15] and made large-scale mono-cropping plantations economically attractive to urban investor. Until the early 1980s, relatively little economically promising new technology was available to farmers in rainfed areas. Watershed[16] is a geo-hydrological unit of area for the development of Rainfed farming. Watershed development has become a trusted tool for the overall development of the village and people living within a watershed area.

10.6 In the words of noted economist, Professor C.H. Hanumantha Rao, "**watershed development has been conceived basically as a strategy for protecting the livelihoods of the people inhabiting the fragile ecosystems experiencing soil erosion and moisture stress**". Watershed projects, launched during 1984 in India, have contributed significantly to the evolution of rainfed technologies and approaches for (a) increasing agricultural production in Rainfed areas through improved land and crop management; (b) On-site moisture conservation; and (c) Production of fodder and fuel in non-cultivated areas. The basic components of the Watershed Approach consist of:

- Community Development (Human Resource Development),
- Soil and Land Management,
- Water Management,
- Afforestation,
- Pasture/Fodder Development,
- Livestock Management,
- Rural Energy Management, and
- Farm and Non-Farm Value Addition activities;

[14] Such investment has focused on extensive and costly Irrigation Systems and Green Revolution (GR) technologies involving high-yielding crop varieties, inorganic fertilizers, and pesticides.

[15] Gopal, KS & Sashi Kumar (1995): ILEIA Newsletter Vol. 11 no 4, 1995) and http: //www. oneworld/ ileia

[16] Watershed refers to a "contiguous area draining into a single water body or a water course" or "it is a topographical area having a common drainage". This means that the rainwater falling on an area coming within a ridgeline can be harvested and will flow out of this area thorough single point. Some refer it as a catchment area or river basin.

(iv) Watershed Management (WSM): A Well Accepted Single Window and Sound Strategy for Efficient Management of Land, Water and Vegetation resources

10.7 If the Water Resource is managed properly, then not only drinking water problem can be mitigated but also the economic condition of villagers in general, and farmers in particular, will also be changed. The **Bahidwadi Village in the District of Ahmednagar Tehsil** has become tanker-free and the villagers are harvesting both Khariff and Rabi crops as water table has gone up from 8 Metres to 5 Metres, after the completion of a Watershed (Shanker Chaterjee, 2002)[17]. Watershed Management (WSM) has been found to a well accepted single window and sound strategy for efficient management of land, water and vegetation resources through community participation for sustainable productivity, resource conservation, ground water recharge, drought moderation, employment generation and social equity. Study reports reveal that benefits derived from Watershed Methodology, could be categorized as follows:

(a) Increase of crop yield by 25-40% in dry land farming;
(b) Reduction of soil loss due to erosion by 30%;
(c) Large Scale Vegetation Cover of barren hill slopes;
(d) Large tracts of marginal lands brought under dry land Horticulture;
(e) Development of Agro-Horti and Agro-Forestry systems;
(f) Harvesting of Water resources through nala bunds, farm ponds, gully embankments;
(g) Regeneration of grass lands for more fodder and grass; and
(h) Considerable increase of income of farmers.

This is due the fact that the development is based on type of soil, depth of soil, vegetative cover, harvestable rain water in that area, watering that area, water budgeting, and treatment given to soils from the ridge to the valley.

[17] Shankar Chaterjee (2002): "Management of Water Resources Changed Economic Conditions of farmers : A Study in Maharashtra", presented at the 2nd International Conference on Sustainable Agriculture, Water resources Development and Earth care Policies, organised by Bhoovigyan Vikas Foundation (An earth care Foundation), 18-20 December 2004, New Delhi.

10.8 The Government of India has accorded highest priority to the holistic and integrated development of rainfed areas (http://agricoop.nic.in/annrep/fnchap3.htm) for: -

- Meeting the projected food grains requirement
- Bridging the regional disparity in terms of production and productivity between the irrigated and Rainfed areas.
- Restoring ecological balance.
- Generating employment opportunities in rural areas.

The Central Government launched the National Watershed Development Project for Rainfed Areas (NWDPRA) during the 8th Plan (covering 25 States and 2 UTs) and continued during the 9th Plan (covering 28 States and 2 UTs) for increasing agricultural productivity and production through sustainable use of natural resources. Also, the Watershed Development Projects in Shifting Cultivation Areas (WDPSCA) was launched in N.E.R. States during the 8th Plan (1994-95) and continued during the 9th Plan also. The Union Budget (1999-2000) suggested establishing a "**Watershed Development Fund**[18]" at NABARD for integrated watershed development in **100 priority districts of 14 states** through participatory approach. Many externally aided projects on integrated watershed development were taken up in States, as given below:-

- Integrated Watershed development Project – Phase II (The World Bank/IDA Credit) – in Shivalik Hills in the States of Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir, and Uttranchal
- Karnataka Watershed Development Project (The World Bank/IDA Credit)
- Assam Rural Infrastructure and Agriculture Support project (ARIASP) (The World Bank/IDA Credit)
- Diversified Agriculture Support Project (DASP) in Uttar Pradesh and Uttranchal.
- German Assisted Project (Kreditanstant for Widderaufbau) in Maharashtra
- DANIDA Aided Projects (Comprehensive Watershed development project) in Tamilnadu, Karnataka, Orissa, and Madhya Pradesh

[18] The Total Corpus of the WDF is Rs. 200 Crores which includes Rs. 100 Crores from NABARD and Rs.100 Crores from the Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India.

- DFID (U.K.) Aided project in Karnataka (Karnataka Watershed Development Project – KAWAD)
- Indo-German Bilateral Project on Watershed Management in the states of Bihar, Gujarat, Madhya Pradesh, Orissa, Maharashtra, Andhra Pradesh, Uttar Pradesh, Himachal Pradesh, Tamilnadu, and Rajasthan.

10.9 There has to be a shift in the approach and strategy of the Watershed programme from the conventional soil conservation approach of **SAFE DISPOSAL OF RUN-OFF** to **RAINWATER CONSERVATION AND HARVESTING** based on indigenous systems and practices, suitably supported by appropriate technology (Planning Commission, 2001)[19]. About 18 million hectares of **Rainfed area[20]**, which is suffering from low yields of crop production and soil erosion due to inadequate vegetative cover, are suitable for agro-forestry (National Forest Policy Draft, 2001)[21].

10.10 Development of the vast rainfed areas (90 million hectares) would require over Rs.37,000 Crores, and scientific treatment for soil and water conservation for 12 million hectares of arable and 3 million hectares of non-arable land would require about Rs.7,500 Crores (Planning Commission, 1997)[22]. The perspective plan that the Tenth Five Year Plan Working Group had proposed is to cover 88.5 million hectares of **Rainfed and degraded lands** in the next four FIVE YEAR PLANS (i.e. upto 2022 A.D.). What about the investment? Will it come from the Government or from the Private? **The investment question, no doubt, is a pertinent issue** and some loud thinking is called for in this regard.

(v) Diffusion of information and locally adapted technologies: An essential ingredient for local empowerment

10.11 Experiences in **Sub-Saharan Africa** (stretching from Senegal in the west to Sudan, Somalia and Ethiopia in the east) have thrown some helpful guidance for planning in Rainfed areas. They provide promising approaches to natural resources management involving close contact between

[19] Planning Commission (2001): The Working Group Report on Rainfed Farming and Natural Resources Management, Report No. 15/2001, Government of India, New Delhi

[20] Rainfed farming means a high-cost cultivation in India.

[21] National Forest Policy (Draft) 2001, Planning Commission, Government of India: Agroforestry helps improving food accessibility, employment generation through diversification in agriculture, conservation and development of natural resources and overall development of the region.

[22] Planning Commission : The Ninth Five-Year Plan Document (1997-2002: Volume II), Government of India

the community concerned and the outsider agency involved, over a period of several years. This time element is important because it takes a long time to develop a series of appropriate activities, which can address priorities of the local people in rainfed areas, use their conventional wisdom, and introduce adaptations which are within their grasp. Alternative way is to build upon successful practices elsewhere, which would certainly permit a far wider diffusion of information and locally adapted technologies.

10.12 We have some success stories, like the transformation brought out in Jhabua district of Madhya Pradesh: e.g. availability of drinking water, low levels of crop failure, availability of fodder, increase in milk yields, and more importantly employment and food security (Anil Agarwal et al, 2001)[23]. In this context, it must be noted that in the Indian approaches followed so far in watershed development programmes, the projects are mostly confined to soil and water conservation measures and plantation activities. The rejuvenation of the Rainfed areas is largely perceived as a "land-based" program with the implicit assumption that ground water recharge as a result of soil and water conservation, will automatically result in better livelihoods of the local people. The reality, on the other hand, is that investments are made without any prioritization of the poor and totally insensitive to the reality of the caste and class structures of the villages. The work of a dedicated NGO in the "**Pushkar Gap Project**"[24] is a revealing study.

10.13 All these clearly show that "a better life for disadvantaged rural people may be more feasibly sought through a different sort of change; through quiet personal revolutions in the perceptions, values and choices of professionals concerned with research, technology and action for rural development" (Robert Chambers, 1984)[25]. Such changes, however, require perseverance and painstaking efforts, taken resolutely in a consistent direction. For bringing about departures in rainfed areas, new kinds of research and extension systems are needed, not only technical support but also to make major changes in terms of the definition of their objectives. Thus the systems devised for extension need to move away from providing "experts" to tell the local people what they should be doing, but to

[23] Anil Agarwal, Sunita Narain and Indira Khurana (2001): "**Making Water Everybody's Business: Practice and Policy of Water Harvesting**", Centre for Science and Environment, New Delhi, 2001.

[24] Pushkar Gap Project: A people led model with "holistic" and "bottom-up" approach for combating deserticification and poverty alleviation – by the Consortium of Indian Scientists for Sustainable Development, New Delhi.

[25] Robert Chambers (1984): "Beyond the Green Revolution: A Selective Essay" - in "Understanding Green Revolutions – Agrarian Change and development Planning in South Asia. Essays in honour of B.H.Farmer" edited by Tim P.Bayliss Smith and Sudhir Wanmali, Cambridge University Press, London, 1984.

move towards the development of staff who can act as "**Catalyst, Convenor and Colleague**" (Chambers, Pacey and Thrupp, 1989)[26].

10.14 Despite 50 years of development planning, **Rainfed agriculture** continues to be the largest and the most important segment of crop production in India. Both the infrastructural facilities and access-to-markets capabilities **influence** developments in the rainfed agriculture (e.g. oilseeds development in semiarid tropics) in India. The need for a second green revolution, by **making grey areas green,** was thus felt (i.e. making rainfed areas more productive) (Paroda, 2000)[27]. There has been a paradigm shift: from a "commodity" centred "**green revolution**" towards an "integrated natural resources management" centred "**evergreen revolution**" in India (Swaminathan, 2002)[28]. While physical access to food was the main consideration during the 80s and 90s, economic and ecological access to food security would be the major challenge in the near future. Fusion of technologies is expected to benefit "rainfed farming" facilitating "**bubble-up**" economics i.e. small farmer based rural economy to build up national economic development, in stark contrast to the failure of "**trickle down**" economics (Moni, 2003)[29].

10.15 The emergence of the new multilevel paradigm in favour of the decentralization of power **provides** an important opportunity to relocate the rights and responsibilities for resource management in the hands of local people. However, much depends on the mode of functioning, and how much resource will be devolved to the local people. Further, the mere devolution of control over resources to local communities will not be enough to ensure a more sustainable development in our dry lands. **Ability to steer through such development with devotion and dedication is fundamental**. It is here that the role of highly motivated and dedicated NGOs becomes relevant.

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[26] Chambers R, Pacey A and Thrupp L.A (1989): "**Farmer First: Farmer Innovation and Agricultural Research**", Intermediate Technology Publications, London, 1989.

[27] Paroda R.S (2000): "Farm Research : Policy Support Essential" published in "Survey of Indian Agriculture 2000", The Hindu Publications

[28] M.S.Swaminathan (2002) : " Who will feed India in 2020" in the Dr.Salim Ali Memorial Lecture

[29] Madaswamy Moni (2003): "Digital Opportunities - A Positive Force for Agricultural Growth, Poverty Reduction and Sustainable Resource Use in India", Theme Paper presented at the National Conference on "**Land Care Movement For Food, Water and Livelihood Security**" organised by Soil Conservation Society of India, at Chennai on 21-23, January 2003; and also see Geospatial Today, Vol. 1 and Issue 6.

10.16 Jodha's (2001)[30] numerous writings on "Fragile Environments" have pointed to the neglect, by the mainstream policy-makers, of people's adaptation strategies to **high-risk –low-productivity** environments through folk technologies and various formal and informal institutional arrangements. To revive these traditional systems, it has been emphasized that the incorporation of these elements is essential viz.: community stake, local control and functional knowledge of the natural resources base. Broadly, the process of globalisation would create circumstances, which are beyond the control of communities in fragile rainfed areas. Since, however, it is not possible to wish away the process of globalisation; the solution would be to influence and modify these processes by adapting to the changes led by globalisation. The specific focus of the steps could be on minimising economic losses, preventing exclusion possibilities, ensuring local participation in the resource harnessing decision, creating compensatory mechanisms for environmental services offered by fragile areas and their people to the rest of society and the economy etc (Jodha, 2001).

10.17 This "**Blue Revolution**" is a step towards water conservation and management, smallholder irrigation, drainage and waste water reuse, to achieve sustainable public health and food security, and ushering "**2nd Green Revolution**", "**Gray Green Revolution**", or "**Evergreen Revolution**" in India. To achieve quick and spectacular results, it is necessary to establish models of appropriate transfer of technology at District, Block, Panchayat and Farm levels spread over the entire country.

(V) Indigenous Technical Knowledge (ITK): Stage set for Exploitation for sustainable use and management of natural resources in agriculture

10.17 Indigenous Technical Knowledge (ITK) refers to the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to particular geographic area (Gremier & Louise, 1998). Mehta and Bandopadhyay (2002)[31] list out that the documentation activities have been undertaken in the following areas:-

[30] Jodha N.S (2001): "**Life on the Edge – Sustaining Agriculture and Community Resources in Fragile Environments**", Oxford University Press, 2001.

[31] Mehta S.L and Bandyopadgyay A (2002): "Sustainable Agriculture: Farming Systems and natural Resources", presented as a Theme paper in the 2nd International Conference on "Sustainable Agriculture, Water Resources Development & Earth Care Policies" organised by Bhoovigyan Vikas Foundation (An Earth Care Foundation), New Delhi on 18-20 December 2002.

- Agro-Animal Based Yarns, Natural Dyes and Weaves
- Crops and Cropping Systems
- Ethno Botany and Agro Biodiversity
- Farm Implements
- Fishery
- Food product development
- Grain and Seed Storage
- Horticulture
- Low cost Housing Material
- Pests and Disease Management
- Post harvest Technology
- Rainwater management
- Soil and Water Management
- Soil Fertility Management
- Tillage and Interculture
- Veterinary Sciences and Animal Husbandry

10.18 The pressure on land has increased to an extent that the relationship between the living beings and the Soil has become critical. Our Soil resources face deterioration aggravated due to:

- Deforestation
- Accelerated soil erosion
- Deterioration of soil physical environment
- Increasing waterlogging and salinity in Canal Irrigated Areas,
- Declining water table due to over-exploitation of Ground Water,
- Poor management of rain water,
- Lower efficiency in Water use and fertiliser (and agro-chemicals), and
- Rapid industrialisation coupled with pollution and environmental degradation.

Mehta and Bandopadhyay (2002)'s study clearly shows that the emerging importance and potential of ITK could usher in WIN-WIN situation for natural resources conservation and management for sustainable agricultural development in India. Ram Kumar (1998)[32] also asserts that the value of ITK

[32] Ram Kumar S (1998) : "Realising the Reality : the First Step in Sustainable Agricultural Development", News Letter of the Agricultural Research and Extension Network, 37:22-24.

has to recognised and blended with scientific information, if the livestock sector is to be improved and sustained. The importance of traditional wisdom and indigenous knowledge & practices to sustainability **is being brought centre-stage** through pooling of traditional knowledge, distilling and evaluating it in the context of modern scientific and technological environment, and harnessing it for sustainable agricultural growth.

10.19 A key element of **the FARM Programme**[33] is the recognition of communities "indigenous knowledge, which when complemented by specialist "formal knowledge" promote participatory learning and research for achieving sustainable use and management of natural resources in agriculture and attainment of household food security through innovative approaches, in rainfed areas.

Let me now focus on the topic of the Day.

11. Climate Change: What does it mean to the Common Public in general? the Farmer in particular?

11.0 Climate Change (CC) means changes in temperatures, precipitation, water stress, floods, cyclones and droughts. Current Climatic Models (CMs) are predicting global warming of about 1.4 to 5.8 degrees centigrade during 21st Century, which will create many challenges to agriculture in terms of economic growth, poverty eradication, land degradation, access to water and food security. Available Research studies provide directional evidences that Climate Change (CC) would influence the biophysical vulnerability of Indian farmers.

11.1 The atmospheric concentrations of key anthropogenic greenhouse gases [Carbon dioxide (**CO_2**), methane (**CH_4**), nitrous oxide (**N_2 O**), and tropospheric ozone (**O_3**)] reached their highest levels in 1990s, primarily due to the combustion of fossil of fuels, agriculture and Land use changes

[33] The Farmer-centered Agricultural Resource Management (FARM) Programme is an initiative of eight Asian countries, viz. China, India, Indonesia, Nepal, Philippines, Sri Lanka, Thailand and Vietnam, and supported by UNDP and implemented by FAO, during 1990s.

(IPCC,2001)[34]. Due to the long span of greenhouse gases in the atmosphere, and regardless of efforts to reduce their emissions, Climate Change (CC) would occur for at least in the middle of the next century. **Adaptation is therefore a necessity**. Planning adaptation must begin with an understanding of vulnerable populations and regions. **Vulnerability[35]** and **Adaptation[36]** are central to International Policy on Climate Change (IPCC), in both United Nations Framework Convention to Climate Change (UNFCCC) and the Kyoto Protocol.

Hazard	:	potential threat to humans and their welfare
+		
Vulnerability	:	exposure and susceptibility to losses
=		
Risk	:	probability of hazard occurrence
Disaster	:	realization of a risk

11.2 Recent experiences, worldwide, show that any change in the critical variables (temperature, radiation, and precipitation) can induce vulnerability of food production in a major way. The IPCC reports show that impacts of Climate Change (CC) in the future would be borne disproportionately by the Poor. Agro-management options have to be identified for sustaining yields under climatic variations. Effective policies and measures are required to safeguard and improve food security and rural livelihoods, as the vulnerable are the landless and the rural poor.

12. Adaptation to Climate Change for Agricultural Productivity

12.0 The issues of Climate Change (CC) and its potential impacts on agriculture have been a major research topic in recent times. Potential

[34] Intergovernmental Panel on Climate Change (2001): "Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change", Cambridge University Press, Cambridge, United Kingdom.

[35] **Vulnerability** - The extent to which climate change may damage or harm a system; it depends not only on a system's sensitivity, but also on its ability to adapt to new climatic conditions. Sensitivity - is the degree to which a system will respond to a change in climatic conditions (e.g. the extent of change in ecosystem composition, structure and functioning, including net primary productivity, resulting from a given change in temperature or precipitation.

[36] **Adaptability** - The degree to which adjustments are possible in practices, or structures of system to projected or actual changes of climate; adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of changes in conditions.

Climate Change (CC) impact on Agriculture will be on Crop Yield variability and Irrigation Demands. Most yield analysis in India showed higher vulnerability to rainfed crops. **Crop Yield Variability** is one of the often-quoted indicators of agricultural impact, due to climatic change. Most yield analysis in India showed higher vulnerability to rainfed crops. Sinha and Swaminathan (1991)[37] estimated that a **2°C increase** in mean air temperature could decrease rice yield by about **0.75 ton/hectare** in the High Yield Areas and by about **0.06 ton/hectare** in the Low Yield Coastal Regions. Rao and Sinha (1994)[38] in their crop-simulation study have estimated that under a 2 X CO_2 climate change scenario, the wheat yields could decrease by 28%-68% without considering the CO_2 fertilization effects. Kumar and Parikh (1998)[39] have shown that even with adaptation by farmers of their cropping patterns and inputs, in response to Climate Change (CC), the loss in farm-level net-revenue is estimated to range between 9% and 25% for a temperature rise of **2°C – 3.5°C.**

12.1 There have been a lot of "deliberations" that Climatic Changes (CCs) could affect food supply and access, through their direct and indirect effects on crops, soils, livestock, fisheries and pests. Long-run investments in land, machinery, irrigation, seeds, fertilisers, etc., are strongly influenced by climate and climate variability (Mac Callaway, 2002)[40]. Climate Change (CC) may further exacerbate the regional differences in the Eastern Region, because these regions with limited irrigation infrastructure are also the areas where agriculture is most vulnerable. Regional climatic data about precipitation, temperature, and extreme events are required to anticipate and plan Climate Change (CC) Adaptation Strategies.

[37] Sinha S.K. and Swaminathan M.S (1991) : "Deforestation, Climate Change and Sustainable Nutrition Security : A Case Study of India", Climatic Change 19, 1991

[38] Rao D.G. and Sinha S.K (1994) : "Impact of Climate Change on simulated Wheat production in India", in Rosenzweig C, Iglesis.A (eds) : Implications of Climate Change for International Agriculture : Crop Modelling Study", Washington D.C., United States Environment Protection Agency

[39] Kumar K.S and Parikh J. (1996) : "Climate Change Impacts on Indian agriculture : the Ricardian Approach" in Dinar et al. (eds) : Measuring the Impacts of Climate Change on Indian Agriculture, World Bank Technical Paper No. 402, Washington DC, World Bank.

[40] Mac Callaway (2002) : "A Framework for conducting benefit cost assessment of adaptation options in the Agricultural sector", UNEP Collaborating Centre on Energy & Environment (Denmark) in South Asia Expert Workshop on "Adaptation to Climate Change for Agricultural Productivity" organised by Government of India, UNEP and CGIAR, 1-3 May 2002, New Delhi.

12.2 According to Ravindranath (2002)[41], Agriculture sector contributes to greenhouse warming (20% of radiative forcing) but at the same time, **provides opportunity** for low cost mitigation options by undertaking CO2 sequestration and Methane & Nitrous oxide emission reduction. Ravindranath (2002) suggests **adaptive measures, which should receive highest priority,** as follows: -

- Increase irrigated areas based on sustainable water resources
- Adopt soil and water conservation measures and prevent land degradation;
- Increase water use efficiency of both Dryland and Irrigated agriculture;
- Develop drought-resistant and pest-resistant crop varieties;
- Develop slat-resistant crop varieties for coastal zones;
- Promote mixed –cropping practices;
- Develop crop varieties adapted to projected Climate Change;
- Improve weather information system

Use of Renewable Energy Sources: A Premier Step to check growth of CO_2 concentration level

12.3 In India, the agricultural production is emerging as an important consumer of commercial energy. Solar Energy has wide prospectus for utilisation in Agriculture, as the sun's energy is available when the Agriculture operations are done. Solar energy is a natural gift and is of prime importance in the field of all energy. Sun is recognised as the father of all sources of energy. Renewable Energy can be used to replace various activities in rural areas and in crop production. **In agriculture, the maximum energy is used in "land operations" and "irrigation"**. The Rural Energy Technology (RET) can substitute the conventional energy sources to a great extent as given below:-

[41] Ravindranath N.H. (2002) : "Benefits of Linking Adaptation and Mitigation in Agriculture & Forestry", South Asia Expert Workshop on "Adaptation to Climate Change for Agricultural Productivity" organised by Government of India, UNEP and CGIAR, 1-3 May 2002, New Delhi.

Options	Operations in Rural Areas based on RET
Solar Energy	Water Pumping for irrigation, Post-Harvest Operations, and Domestic Cooking
Biogas	Fuel for Domestic Use
Biomass	Domestic Cooking

12.4 The Restricted supply of electric power and the frequent shortage of diesel oil pose the most disturbing and immediate problem, to an individual farmer. Due to its perennial availability, the solar energy will remain a favoured option for sustainable development of agriculture. Serious efforts are required to save as much of our installed electrical power of about 100,000 MW, through use of renewable energy sources (RESs), which will check the growth of the CO_2 concentration level. The cost of power generation from RESs is comparable if the environment cost is also accounted for. The extensive use of RESs to complement the existing energy sources is an option to sustainable energy flow in rural areas (Mathur, 2002)[42].

Agricultural Ecology Network for Capacity Building at Grassroots level: A pre-requisite for adaptation to Climatic Change

12.5 With Climate Change (CC) and Globalization occurring simultaneously, the Indian agriculture is confronted by the impacts of both the processes. What are lacking in the available literature are the potential interactions between the effects of Climate Change and the Ongoing Economic Changes. There is an urgent need to integrate the Socio-Economic Components into Biophysical model, which will require the **base line data** on the following:

- Climatic Scenarios: Spatial-temporal pattern of temperatures and precipitation
- Socio-economic: population (density, growth, urban, coastal, Below Poverty Line) ; Income (GDP, AgGDP,

[42] Mathur A.N (2002): "Sustainable Agricultural System : Reduced Reliance on Non-Renewable Energy Sources and Substitution of Renewable Energy Sources", presented as a Theme paper in the 2nd International Conference on "Sustainable Agriculture, Water Resources Development & Earth Care Policies" organised by Bhoovigyan Vikas Foundation (An Earth Care Foundation), New Delhi on 18-20 December 2002.

Growth); Land (Ownership, Use, Net Cultivated Area, Gross Cultivated Area), Labour Force; Asset

- Resource: land, Livestock and Capital assets, Energy use, Irrigation;
- Bio-diversity: Diversification of Cropping Pattern

Change over base line:

- Demographic variables (Population density, Sex ratio, etc)
- Land Use and Land Degradation
- Pollution: Magnitude, Health Hazards
- Economic: Poverty, Income, Sectoral Composition
- Social: Literacy, disaster deaths

12.6 Agricultural Production on a sustainable nature depends on the judicious use of natural resources like soil resources, water resources, animal resources, crop/plant genetic resources, in an acceptable technology management under the prevailing Socio-economic infrastructure at grass-roots in India. Climate adaptation and sustainability goals (resilient sustainable development) can be jointly advanced by changes in policies that lessen pressure on resources, improve management of environmental risks, and enhance adaptive capacity. Negative impacts of Climate Changes (CCs) can be limited by:

- **Changes** in crops and crop varieties,
- **Improved** water management and irrigation systems,
- **Adapted** planning schedules and tillage practices, and
- **More scientific** land use planning.

12.7 Indian Agriculture has provided food, feed, nutrition, employment and environmental securities to the ever increasing population of human being and livestock. Increased climate variability and long-term changes in Climate will hamper Farmer's adaptive efforts (World Bank, 2003)[43]. Grass-root level research should be directed towards environmental issues such as Climate Change (CC), Loss of Biodiversity, Soil degradation

[43] World Bank (2003): Concept Paper circulated in the "Multi-Stakeholder Regional Consultation for International Assessment on Role of Agricultural Science and Technology in Reducing Hunger, Improving Rural Livelihoods and Stimulating Environmentally Sustainable Economic Growth", 12-13 May 2003, New Delhi..

and Water-Level-Pollution versus farm-level technologies for improving Crop, Fisheries, Forestry and Livestock production.

12.8 A **Climate Change Network Project** (Agro-Climatic Zone wise) has been launched by the Indian Council of Agricultural Research (ICAR), during the 10th Plan **for comprehensive understanding of impacts, adaptation, and mitigation strategies** for various crops and cropping systems. There have suggestions from various corners that, to promote networking, training, capacity building and documentation/dissemination of best practices, technologies and success stories, it was essential to envisage **a National Centre for Agricultural Ecology (NCAE)** at New Delhi. Lester Brown (2002)[44] suggests an economy for the Earth - "**Eco-economy**" - that respects the principles of ecology which can be integrated into eco-systems, in a way that will stablise the relationship between the economy and the earth, enabling economic progress to continue.

13. Integrated Water Resources planning and Management at Grassroots Level for adaptation to Climate Change & Sustainable Agricultural development: Need for an Informatics Blueprint

13.0 The Dublin Statement (1992) on Water and Sustainable Development and Agenda 21 of the UN Conference (1992) in Rio de Janeiro stressed on the need of/for intensive efforts to appropriately develop and efficiently manage the world's scarce fresh water resource, based on a participatory approach involving Users, Planners and Policy Makers at all levels. The Global Water Partnership (1996) recognised the advantage of ICT developed and made available globally.

13.1 Water Resources development and management is an Information System. An Information System (IS) is defined as components that work together to provide desired information, in the proper format, at an appropriate time. System, which can have numerous subsystems and sub-subsystems, is the term used to describe any combination of related elements that work together to achieve a desired goal. The National Water

[44] Lester R. Brown (2002) : "Eco-Economy : Building for the Earth", Orient Longman private Limited, India, 2002

Policy (2002) has envisaged **a well developed information system**, for water related data in its entirety, at the national / state level, is a prime requisite for resource planning.

Exchange of information between Hydrological Science and Water Managers

13.2 In the Water sector, it is important to distinguish between the needs of those who wish to estimate the potential magnitude of Climate Change impacts on hydrology and water resources—to meet IPCC concerns, for example—and the more pragmatic needs of Water Managers who need to consider how best to adapt to Climate Change. The two sets of requirements are linked, but there are some important differences in emphasis (IPCC, 2001)[45]. Such research questions need developments in the following areas:

- Creation of credible climate change scenarios.
- Characterization of natural climatic and hydrological variability.
- Improved hydrological models (Particularly important is development and application of process-based models of hydrological processes that include realistic representations of processes that generate stream-flow and recharge and determine water quality).
- Characterization of uncertainty. How important are the different sources of uncertainty—in emissions, global climate response, and regional climate change— for estimated effects of climate change?
- Impacts on real-world water systems (Characteristics of the Water Management System are a very important buffer between hydrological effect and impact on users and the environment.)
- Effects of adaptation. Most impact studies have ignored adaptation by water managers, and in opposition, it often is asserted that water managers will be able to adapt. However, how will managers make adaptation decisions in practice on the basis of incomplete information, and what

[45] IPCC (2001): Third Assessment Report of the Inter-Governmental Panel on Climate Change (Working Group II): Impacts, Adaptation and Vulnerability, UNEP & WMO, 2001.

would be the effects of inefficient adaptation on the impacts of climate change?

13.3 Efficient adaptation to Climate Change in the Water Sector requires effort in five main areas:

- Data for monitoring. Adaptive water management requires reliable data on which to make decisions, calibrate models, and develop projections for the future. These data should cover not just hydrological characteristics but also indicators of Water Use.
- Understanding patterns of variability. An understanding of patterns of variability—in particular, the stability of a "baseline" climate—is important for medium-term water management. It is increasingly recognized that even in the absence of climate change, the recent past may not be a reliable guide to the hydrological resource base of the near future.
- Analytical tools. Effective water management requires numerous tools to assess options and the future. These tools include scenario analysis and risk analysis, which are used in some parts of water management but currently are by no means widespread.
- Decision tools. Scenario and risk analysis provides information on possible futures and their consequences. They must be supplemented with tools such as Bayesian and other decision making tools to make decisions on the basis of the information provided. Again, techniques for decision making under uncertainty are not widely used in water management at present, and some of the approaches being used are not very sophisticated.
- Management techniques research into specific aspects of many demand-side approaches in particular, as well as into opportunities for Seasonal Flow Forecasting and innovative Water Supply and Treatment Technologies (such as desalination).

13.4 The above efforts are needed to improve water management even in the absence of Climate Change (CC), and there is an overarching need

to improve the exchange of information between Hydrological Science and Water Managers. Water Managers have long been accustomed to dealing with change, although until recently this has been primarily change resulting from changes in demand and altered legislative or statutory requirements. Climate change does not in itself stimulate development of new adaptive strategies, but it encourages a more adaptive, incremental, risk-based approach to water management. More precisely, it provides further encouragement for a trend that already is gathering pace.

Decision Support System (DSS) on interaction effects

13.4 The interaction effects of CO_2, rainfall and temperature can be best studied through the use of Crop Growth Simulation Models (i.e. **InfoCrop** of Indian Agricultural Research Institute, New Delhi). The **InfoCrop** Model deals with crops such as: chickpea, cotton, groundnut, maize, mustard, pearl millet, pigeon pea, potato, rice, sorghum, soybean, sugarcane and wheat, and has taken into consideration the "growth and yield loss" due to insects, weeds and diseases.

13.5 This IARI DSS Model facilitates to explore the window of opportunities for land use planning and food security of a region by integrating natural resources inventory, biophysical simulation of a agricultural production potential, and socio-economic goals and constraints. This model uses GIS technology, RS technology, Database technology, Crop & Livestock Model, and also an Optimization model. Efforts are now being made to upscale for the national level as well as to down scale to "village & farm level" (Samra, 2002)[46].

E-Governance & Sustainable Development: A Paradigm Shift for Grassroots Level Development

13.6 Emergence of Information Technology on the national agenda and the announcement of IT policies by various State Governments have recognised the "**Convergence of Core Technologies and E-Governance**" as

[46] Samra J.S (2002): :Impacts, Adaptation and Mitigation of Climate Change I Indian Agriculture", presented as a Theme paper in the 2nd International Conference on "Sustainable Agriculture, Water Resources Development & Earth Care Policies" organised by Bhoovigyan Vikas Foundation (An Earth Care Foundation), New Delhi on 18-20 December 2002.

the tool for sustainable development and globalisation of economy. Models of Digital Governance (e-Governance) are continuously evolving and improvising to harness the potential offered by the Information and Communication Technologies (ICTs) and deal with new realities in the area of governance. **There are no rigid and finite models of Digital Governance.** In fact, several developing countries are putting into practice innovative e-Governance models that may technologically simple but are changing the way information is distributed in the society.

13.7 Based on primary experimentation and secondary research, **a few generic models** (**http://www.digital governance.org**), which have emerged and are being practiced, have been identified, on the basis of: emergence of knowledge societies and knowledge networkers, role of information in governance process, and link between ICT and governance, **are as follows**: -

- **Broadcasting / Wider-Dissemination Model**: National and Local Governments in developing countries need to aggressively adopt this model if they want to enhance participation of citizens in the governance processes.
- **Critical Flow Model:** Different organizations can use it differently depending on the aspect of governance they want to address. By focusing on the critical aspect of information and locating its likeable users, the model corrects information failure, raising awareness about the bad governance practices, and acts as a hindrance to bad governance practices.
- **Comparative Analysis Model:** Developing countries could very effectively use this comparative model as ICT opens their access to the global and local knowledge products at a relatively low-cost. The model however becomes ineffective in absence of a strong civil society interest and public memory that is essential to force decision-makers to improve existing governance practices.
- **E-Advocacy/ Lobbying and Pressure Group Model:** The model enhances the scope of participation of individuals and communities in debates, which affect them and help them, build a global alliance.
- **Interactive-Service Model:** The potential of ICT for the governance is fully leveraged in this model and leads and can

bring lead to greater objectivity and transparency in decision-making processes. This Model facilitates establishing decentralised forms of governance (G2C2G or G4C4G).

13.8 All these models share in common, the inherent characteristics of the new technologies, which are: (a) enabling equal access to information to anyone who is a linked to the digital network and (b) de-concentration of information across the entire digital network. **Geometry of Information Flows** is a detailed human-centric picture of information flows in a society. It focuses on "***Who are the people***" getting connected and are benefiting when there is an increase in information access and flow.

13.9 Studying and influencing "Geometry of Information Flows" is important **because the aim is to use ICT for development purposes---those that bring real, significant changes in the lives of disadvantaged communities** rather than simple embedding of ICT in the society. Somewhat detailed steps, as available from published materials, **for e-Governance projects** are given below: -

- Who are our Target groups that we want to reach out to, through ICT for Development projects?
- What are the key information needs of the disadvantaged community?
- What are the existing channels by which information reaches to the disadvantaged community?
- What is the weakest link in the chain of information flows: from source to the disadvantaged community?

Guiding principles of designing ICT for development projects are: -

- Focus on the Disadvantaged Communities, who otherwise will be excluded
- Provide that information or service which otherwise will not be provided
- Focus on utilizing and where possible building upon what is existing rather than thrusting a new intervention
- Create an outcome which in absence of ICT, will not be produced efficiently or timely
- Understand the difference between direct benefits and trickle-down benefits for the disadvantaged community.

13.10 E-government is more about putting together the IT infrastructure to make the average citizen's interface with the government easier, while e-governance has more to do with the laws and regulation of the Internet. E-government differs from the basic tenets of ICT (computerization and connectivity) by adding an element of interaction with citizens or the private sector, enhancing transparency, and providing "voice" for those outside the government. Initially it was referred to as G2C (i.e. Government to Citizen) and now is defined as G4C (i.e. Government for Citizen). The famous voice of Abraham Lincoln runs like this: "Government of the People, Government for the People, and Government by the People". This is the appropriate definition for "e-Governance" / "e-Government". The ongoing World Bank aided "National Hydrology Information Network", thus, needs evaluation, in view of the emerging "convergence & e-Governance" paradigm in the Country.

Digital development in Rural Areas: A Journey started in 1985 with the establishment of NICNET in districts of India

13.11 In India, "district" is the basic administrative unit at the sub-state level and also consistent with the decentralized planning process prevailing at the grass-root. With the establishment of NICNET in districts numbering about 520 in 1985-87, National Informatics Centre (NIC) has launched its "**district information system (DISNIC)[47]"** in about 28 sectors viz., **agriculture, animal husbandry, education, health, industries**, **rural development**, **micro-level planning**, etc., as an informatics tool for development planning and responsive administration.

13.12 Indian village is a cognizable unit located in a specific agro-ecological and sociological environment. Its potentials and constraints for development are well known. As of today, the development planning is a highly compartmentalized activity managed by atomized government departments handling agriculture, rural enterprises, forests, fisheries, water, health, education, culture, technology and livelihoods - almost in isolation of each other through different projects that rarely converge.

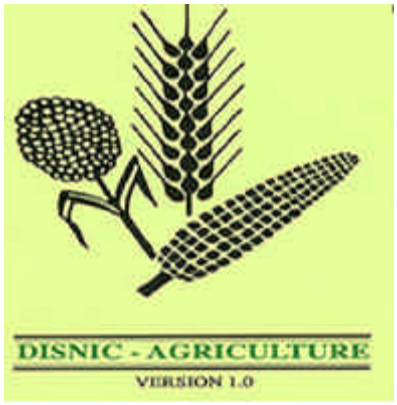
[47] DISNIC – District Information System Programme of NIC, National Informatics Centre, Government of India, 1987.

13.13 Village problems are inter-related and the resources (natural and human) are integrated. People are both the "end and means" of development and also bound by a common space, history, culture and know-how. Indian villages are still complex, intertwined and multi-faceted. The database project to facilitate micro-level planning (**DISNIC-PLAN)** was one among the 27 sectors in 1990s. The DISNIC-PLAN new initiative, during 2004-07, will support building up databases & decision support systems, and communication systems to facilitate: sustainability of resources, poverty alleviation, empowerment of women, full employment, production systems planning, infrastructure planning and habitat planning. Production potentials of village through "circular-flows" and "chain-effect" should be understood.

13.14 The Objective of the project was to come out with an "Informatics Blueprint" that covers Villages (i.e. Informatics for Development Program at the grassroots level in India). "GEOGRAPHY is the study of manifestation of the constant tussle between the MAN and the EARTH", and has two bases: (i) the scientific study of the earth as a system: the Land, Air and Water; and (ii) the humanistic study of man's way of life controlled / determined by the Land. **Water and Climate**, as components of physical environment, decides the economic activity and the way of life including socio-cultural development (Gopalakrishnan, 2004)[48].

Digital Initiatives in Indian Agricultural Sector

13.15 According to the National IT Task Force (1999) recommendation (No.79), "the Government shall take all necessary steps to boost IT for Agriculture and Integrated rural development". The Ministry of Agriculture and National Informatics Centre (NIC) emphasized informatics for agricultural development in the National Conference on "Informatics for Sustainable Agricultural Development (**ISDA-95**), way back in 1995. India is expected to become **a "Knowledge Society" by 2008** and by which time, any farmer in a remote village can demand and get information viz., landuse planning for cropping strategy for farmers fields based on



[48] Professor Gopalakrishnan, Head of the School of Earth & Atmospheric Sciences, Madurai Kamaraj University in his Address to the National Workshop on DISNIC-PLAN held on 27-28 August 2004 at Madurai..

integrated information on soil, water, weather, fertiliser and pest management models; how and where to get proper seeds or good quality nursery plants; prevailing prices of farm equipments, agricultural produce, products and series of such set of information, which can lead to high productivity and optimum cost benefit to the farmers.

13.15 As a step towards "reaching" technology to the small Holders (Resource-Poor- Farmers) of the Country, the Central Ministry of Agriculture have taken initiatives to build up an Informatics Network - AGRISNET: A NICNET based Agricultural Informatics & Communication - during the Tenth Plan. This ICT Network envisages to facilitate an integrated approach of "Internet Technology" and "Sustainable Agricultural, Rural and Backward Area Development" with its farm and non-farm linkages. During the Ninth Plan (i.e. during 1997-2002), the AGRISNET was suggested to have nodes upto "block level", as "block" is the planning unit for agricultural development. To usher in "agricultural Governance"[49] in the country, it is essential to make the AGRISNET as the "rural infrastructure" reaching upto 6.5 lakhs villages. This digital initiative is based on the recommendations of ISDA-95 Conference (Informatics for Sustainable Agricultural Development), which includes among the others, the following Informatics Networks: -

- **AGRISNET** - an Infrastructure network upto block level agricultural offices facilitating agricultural extension services and agribusiness activities to usher in rural prosperity
- **AGMARKNET** with a road map to network 7000 Agricultural produce wholesale markets and 32000 rural markets
- **ARISNET -** Agricultural Research Information System Network
- **SeedNET -** Seed Informatics Network
- **CoopNet** - to network 93000 Agricultural Primary Credit Societies (PACS) and Agricultural Cooperative Marketing Societies to usher in ICT enabled services and rural transformation
- **HORTNET** - Horticultural Informatics Network

[49] -Agricultural Governance means e-Governance in agricultural sector.

- **FERTNET** - Fertilisers (Chemical, Bio and Organic Manure) Informatics Network facilitating "Integrating Nutrient Management" at farm level
- **VISTARNET** - Agricultural Extension Information System Network
- **PPIN** - Plant Protection informatics Network
- **APHNET** - Animal production and Health Informatics Network networking about 42000 Animal Primary Health Centres
- **FISHNET** - Fisheries Informatics Network
- **LISNET** - Land Information System network linking all institutions involved in land and water management for agricultural productivity and production systems, which has now evolved as "**Agricultural Resources Information system**" project during the Tenth Plan being implemented through NIC.
- **AFPINET** - Agricultural & Food Processing Industries Informatics Network
- **ARINET** - Agricultural and Rural Industries Information System Network to strengthen Small & Micro Enterprises (SMEs)
- **NDMNET**- Natural Disaster Management Knowledge Network in India
- **WeatherNET**- Weather Resource System Information Network of India

13.16 India is a land of diversity with different types of terrain, various agro-climatic conditions, different levels of socio-economic conditions, and varied levels of regional development. Informatics Networks, besides Computer Networks, are increasingly considered as development tools for achieving:

- Reaching the Unreached : Public Services
- From Digital Divide to Digital Opportunities for sustainable development and economic growth.
- Fostering agricultural growth, poverty reduction and sustainable resources use.
- Sustainable Development & Earth Care Policies - Water, Energy, Education, Health, Agriculture & Rural Development, Biodiversity

- A Cluster of Villages - Sustainable Societies in Viable Rural Space

Internet based communication, transactions, feedback, and follow-ups, **have thrown up enormous opportunities and challenges** for: learning and counter-learning, moves and counter moves, mobilisation and counter-mobilisation, and opinion making and breaking. "Networking of People" and "Networking of Information" through localization are essential. Distributed databases (WWW information resources, Multimedia databases, Mobile databases, Genome Databases and Digital Libraries) are the converging points of networking the database technologies to bring "**Power to the People**" for planning and bringing in responsive administration (**e-Governance**) in developing countries.

13.17 Emergence of Information and Communication Technologies (ICTs) on the national agenda and the announcement of ICT policies by various State Governments, since 1995, have recognised the "**Convergence of Core Technologies and E-Governance**" as the tool for sustainable development and globalisation of economy. The extent of the use and application of scientific, technical and social information to advance development determines the progress of a nation. There are no rigid and finite models of Digital Governance. In fact, several developing countries are putting into practice: innovative e-Governance models that may technologically simple but are changing the way information is distributed in the society (Broadcasting / Wider-Dissemination Model, Critical Flow Model, Comparative Analysis Model, E-Advocacy/ Lobbying and Pressure Group Model, and Interactive-Service Model).

13.18 ICT accelerates globalisation and make access to knowledge and information much easier for the people to attain "rural prosperity" in respect of: Creation of technologies (- IPR Divide), Diffusion of recent Innovation (- Digital Divide), Diffusion of old Innovation (- Extension Divide), and Diffusion of human skills (- Educational skills). One of the major problems of using ICT for rural prosperity is language barrier i.e. "localization". Over the years, the Government of India, its institutions and collaborators have striven towards enabling the Internet to support "multiple" Indian scripts and languages. A "**national policy o n localisation**" is anvil.

14. Agricultural Resources Information System – A Needed Informatics Blueprint

14.0 The scientific management of Agricultural Resources becomes a very important part of modern agricultural production in the 21st Century and is a new direction in the domain of agricultural engineering. Agriculture is highly dynamic in nature, because of the changing phenomenon of agricultural crops, which is further complicated by the interaction of crops with environment. A wide range of agricultural practices could be effected including potential environmental benefits that could come from minimizing adverse impacts, by reducing external inputs and greater use efficiency. **Precision farming** is one of the most scientific and modern approaches to sustainable agriculture that is gaining momentum in the new millennium. This approach serves the dual purpose of **enhancing productivity** and **reducing ecological degradation**, as it deals with the question of **where** and **when**. Farmers, Land and Natural Resources (supported by the Land) have intrinsic and dynamic relationship. **Resources Application and Agronomic Practices are to match with soil attributes and crop requirements, as they vary across a site**"[50]. A **stocktaking and diagnostic survey** is needed early in the planning process to provide information about the wide range of factors, among the others, influencing agricultural performance:

[50] McBratney and Pringle (1997): Spatial variability in soil-implication for precision agriculture. In J.V. Stafford (ed) Precision Agriculture? 97. Bioss Scientific Publ. Ltd., Oxford, United Kingdom. Vol. I: 3-31.

- Agro-climatic data
- Agro-economic data
- Agro-forestry Resources
- Animal Resources
- Capital Resources
- Climate Resources
- Crops and Cropping Systems
- Environment data
- Fisheries Resources
- Forestry Resources
- Institutional Resources
- Land owners data
- Plant Resources
- Socio-economic & Infrastructure data
- Soil Resources
- Spices Resources
- Water Resource

14.1 Mollet (1984)[51] provides details on the contents of Agricultural Resources Information System and **recommends data and information** on basic resources such as (i) soil resources, (ii) water resources, (iii) climate resources, and other data sets (collated from Remote Sensing as well as conventional means) such as (iv) basic data on crops, (v) animal husbandry and fisheries, (vi) genetic (plant, animal & fisheries) materials, (vii) land ownership, (viii) Socio-economic data, (viii) infrastructure for agricultural development. Zhu Zesheng and Sun Ling (1996)[52] has proposed a seven-layered architectural model has been proposed agricultural resources management: application layer, management layer, decision models layer, decision data layer, production data layer, weather data layer, and environmental data layer. This layered approach is essential to build up required Agricultural Research Information System (AgRIS) in districts, in order to develop decision support systems (DSSs), as listed below, appropriate advisories to the Small and Marginal Farmers (SMFs) :-

- Crop Suitability based on factor endowment
- Land Suitability Assessment;
- Land Productivity Assessment;
- Population Supporting Capacity;
- Land Evaluation and Land Use Planning;
- Land Degradation Risk Assessment;
- Quantification of Land Resources Constraints;

[51] **Mollet, J.A (1984):** "Planning for Agricultural Development", Croom Helm (London & Canberra), St.Martin's Press, New York, 1984

[52] Zhu Zesheng and Sun Ling (1996) : "GIS Implementation of management System of Agricultural Resources" in http://www.esri.com/library/userconf/proc96/TO350/ PAP341/P341.htm .

- Land Management;
- Agro-ecological Characterization for Research and Planning;
- Agricultural Technology Transfer;
- Agricultural Inputs Recommendations;
- Farming Systems Analysis and Development;
- Environmental Impact Assessment;
- Monitoring of Land Resources Development.
- Livestock (cattle, buffalo, goat, & sheep) Farming Systems
- Water allocation in an irrigation system
- Fodder Resources Development
- Water Bodies (Basin) Planning Systems using Watershed and Agro-Eco Region Planning Concepts

The Report of the Core Group-V (AgRIS Report, 2000) of the Standing Committee on Agriculture and Soils suggested strengthening "Agricultural Resources Information System" in all districts (regions) of the Country, "irrespective of past or future growth regions" (**Figure-1**). The Report also recommended pilot projects on the basis of Agricultural Production Systems (viz. Arid Agro-Ecosystem, Coastal Agro-Ecosystem, Hill & Mountain Agro-Ecosystem, Irrigated Agro-Ecosystem, and Rainfed Agro-Ecosystem), for which the typologies considered to be:

- **A tribal district**
- **A hill district**
- **A dryland farming district**
- **A socially backward district**
- **A green revolution district**
- **A district dominated by cash crops**
- **A coastal district**
- **A district in a mining/ industrial belt**
- **A district dominated by forest economy**
- **A dairy farming district**
- **A district dominated by one or two urban centers**
- **A district in arid-zone**
- **A district which is flood prone but having vast wasteland that could be used to generate forest cover**

The Pilot project demonstration in districts of above mentioned typologies, in each state, will facilitate development of decision support

systems (DSSs) on "production practices and systems" which need to be adapted to respond to new market demands and export opportunities, poverty alleviation or growing labour shortages, depending on the setting (NATP, 1998). Development of Agricultural Resources Information Systems, using Geomatics Technology in pilot districts **with public funding, has been sanctioned as a scheme during the Tenth Plan (2004-07).**

Development of Agricultural Resources Information System (AgRIS) is the way forward for "Integrated Water Resources Planning and Management at Grassroots level" in days to come. This is an quintessential requirement for adopting "More Crops per Drop" as well as for adapting to Climate Changes in order to facilitate for sustainable agricultural development in India. The Government Digital Initiatives: **DISNIC Programme** as well as **AgRIS Programme** at grassroots level will provide the necessary "Informatics Blueprint" for adaptation to climatic changes for sustainable agricultural development in India.

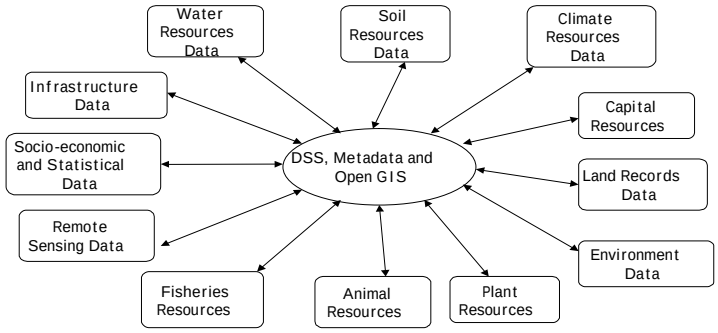


Figure1: Components of Agricultural Resources Information Systems

The paper makes a powerful plea for an Informatics Blueprint for Integrated Water Resources Planning and Management at grass roots level in relation to climate change and sustainable agricultural development. In this context, a comprehensive analysis has been attempted, which starts with a broad-brush picture of existing water resource development

strategies, and policies, with special reference to water in Agricultural production, its access and equality issues, problems of drinking water supply and its quality issues at the grassroots level. Against this background, the paper pleads for a ***plan of action*** to protect, allocate and manage water resources judiciously with a water accounting and budgeting system at various spatial levels to ensure water security, food security, livelihood security, health security and ecological security for the people. **A key recommendation in this context is the setting up of an institution, bringing together the School of Earth Sciences, Colleges of Agriculture, Departments of Geography, School of Environmental Sciences, and Centres of Water Resources Development as well as University Departments specializing in this field.**

The focus in the latter half of the paper is on sustainable development and management of water resources in the light of the Agenda 21 scenario and ICT Diffusion Developmental Action Research. This will be pioneered by the Geography Departments in the country (turning out 15,000 qualified geographers every year) working with Geo-hydrological units for development of Rainfed farming, with a sound strategy for watershed management of Land, Water and Vegetation resources. Some success stories and studies of rainfed farming, facilitating "**bubble-up**" economies i.e. small farmer-based rural economy and their methodologies have been cited.

The last part of the paper focuses on climate change, its biophysical vulnerability on Indian farmers and adaptation strategies for meeting the change, including use of renewable energy resources. A few generic models with link between ICT and governance e.g. Broadcasting / Wider-Dissemination Model, Critical Flow Model, Comparative Analysis Model, E-advocacy / Lobbying and Pressure Group Model, Interactive Service Model etc. The paper concludes with the need for wider diffusion of the latest digital development strategy for Rural areas, ushered in by the NIC, through its new initiative of the DISNIC Plan during 2004-07, which will support building up data bases and decision support communication systems, to facilitate sustainability of resources, poverty alleviation, improvement of

women, full employment, production systems planning, infrastructure planning and habitat planning. Thus the DISNIC Plan project will come out with an ***Informatics Blueprint*** providing Informatics for Development Program at the grassroots level. With Water, the ***elixir of life***, and now a ***scarce commodity,*** as the starting point and the central pillar of development strategy, the paper covers a wide spectrum of issues and problems relating to Integrated Water Resources Planning and Management, providing a Blueprint for accelerating broad-based rural growth, leveraged through the new Information and Communication Technologies to achieve sustainable development in the truest sense of the phrase. . The Government Digital Initiatives: **DISNIC Programme** as well as **AgRIS Programme** at grassroots level will provide the necessary "Informatics Blueprint" for adaptation to climatic changes for sustainable agricultural development in India.

To end, I wish to quote from Thirukkural, which is our ancient Tamil literature.

St. Thiruvalluvar, the Tamil Poet and a Philosopher of 1 B.C. Century, gives an account of importance and relation among "**Climate**", "**Water resources**", "**Water Management**", "**Society**", and "**Economy**" in the Chapter:2 (Kural Venpa 11-20) and the "treatise on Agriculture" in the Chapter 104 (Kural Venba 1031 – 1040), in a very succinct manner. This Chapter talks about the "Van Sirappu: Glory of Rain" and decisively portrays that:

"Neerindru Amaiyaadhu Ulahu": "Water resource is very basic for the Earth"
"Vinhindru Poippin: If the Water from Sky fails"
"Puyalennum Vaari Valamkundrik kaal : if the Sky becomes dry"
"Visumbin Thuli Veezhin Allal: but for the drops of the Sky"
"Nedunkadalum Thanneermai Kundrum: the Ocean will shrink"

These treatises on the "glory of rain" reiterates that water is a prime natural resource, a basic human need and a precious national asset.

Brief Summary of C.V. of

M.Moni, Deputy Director General, NIC

Madaswamy Moni is a senior technocrat of National Informatics Centre (Department of Information Technology, Government of India), currently working as its Deputy Director General. With more than 24 years of professional experience, he has held several prestigious assignments, including sharing important responsibilities as Principal Systems Analyst to the Former Finance Minister of India during 1985-88. He pioneered to establish the District Information System of National Informatics Centre (DISNIC) in 27 Sectors of importance, which included Agriculture, Education, Industries, Rural Development, Microlevel Planning, Animal Husbandry, Fisheries, Water Resources etc, for implementation in about 520 districts of India, with the establishment of NICNET in districts, during 1987-96. One such Project Component (DISNIC-PLAN) has received national level appreciation and has been included as one of the recommendations of the National Task Force on Information Technology and Software Development (1999). His paper titled "**DISNIC - A NICNET Based District Government Informatics Programme in India**", presented at Indian Computing Congress (1991) at Hyderabad was appreciated as a policy paper on "informatics development strategy" at grass-roots level.

His forte is ICT Diffusion and Infusion for achieving sustainable agricultural and rural development in India. He was instrumental in organising the national conference on "Informatics for Sustainable Agricultural Development (ISDA-95)" in May 1995, which gave the "road map" for ICT

diffusion in the agricultural sector. His Paper titled "**Digital Opportunities: A powerful Force for fostering Agricultural Growth, Poverty Reduction, and Sustainable Resources Use in India**" has generated a good amount of academic interests.

Madaswamy Moni has been propagating an integrated approach of "**ICT and Agricultural, rural and backward area development**", with its farm & non-farm linkages, to facilitate sustainable development, sustainable consumption, and sustainable livelihood of rural people. His initiatives such as "**DISNIC-AGRIS**", "**AGMARKNET – Agricultural Marketing Network**" and "**AGRISNET-Agricultural Informatics & Communication Network**" to "**Reach the Unreached**", will have the opportunities to learn of and benefit from new and improved agricultural practices, to have weather-forecast-based guidance for timely agricultural operations, to be alerted by satellite surveys of pests and diseases, and to access crop-output forecasting and marketing strategies for domestic and for export trade.

His mission is "**ICT Diffusion and infusion in primary, secondary and service sectors for increasing productivity and growth**" which has engendered the organization of two international conferences (i.e. Sustainable Development & Sustainable Lifestyles - 2001, Sustainable Agriculture, Water Resources Development and Earth care Policies - 2002). As the Secretary General of the Bhoovigyan Vikas Foundation (An Earth Care Foundation in India), he is instrumental in generating renewed interests in issues of sustainable development among the relevant professionals in India. The following books edited along with his guru Dr.K.V.Sundaram, as a result of international conference organised by the Foundation, shows his immense interest in sustainable development issues:

- "**Reshaping Our Earth View : Creative Thoughts and Alternative Futures**", (Eds) K.V.Sundaram and M.Moni, published by Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2002
- "**Sustainable Development and Sustainable Life Styles**", (Eds) K.V.Sundaram and M.Moni, published by Northern Book Centre, New Delhi, 2002.

- "**Natural Resources Management and Livelihood Security - Survival Strategies and Sustainable Policies**", (Eds) K. V. Sundaram, M. Moni and Mrityunjay M. Jha, published by Concept Publishing Company, New Delhi, 2004.
- "**Restoring Human Culture and Biospheric Environment**", (Eds) K. K. Chakravarty, K. V. Sundaram and M. Moni, published by Northern Book Centre, New Delhi, 2003.

Madaswamy Moni has visited many African, European and Asian countries on various technical missions. His research interests span over a wide area of agricultural economics & informatics, micro-level planning, regional and sustainable development, information systems and networking (ICT), decision support system and fusion of technologies for increased agricultural productivity. He has many publications to his credit. His lectures on "Convergence of Core Technologies & e-Governance as a Tool for Sustainable Development and Economic Growth", and his paper titled "Impact of Economic Reforms on Indian Agriculture: Application of Geomatics Technology to reduce Risks and Vulnerability of Small & Marginal Farmers" require a special mention here.

Madaswamy Moni is a distinguished Vice-President (Indian Representative) in the "**Asian Federation of Information Technology in Agriculture**" (AFITA) for 2004-2006. The Centenarian Trust (Chennai) has conferred on him with the title "**Seva Ratna**" for his contributions in extending the applications of Information and Communications Technology to agriculture and rural development in India in January 2004. The Organising Committee of the National Conference on Land Use / land Cover and Management Practices (held on 21-22 August 2003, Hyderabad) under the aegis of Centre for Land Use management (CLUMA) Hyderabad, MS Swaminathan Research Foundation (Chennai), Bhoovigyan Vikas Foundation (New Delhi) and Department of Agriculture (Government of Andhra Pradesh) conferred "Citation" for his "Outstanding and distinguished contributions in the field of Communications and Information Technology through out his illustrious career towards the cause of developments of informatics for sustainable agriculture developments in the Country".

He has been the champion of promoting and implementing ICT projects in the Agricultural & Rural Development Sector. Recently the AGMARKNET Programme, conceptualized by him and being implemented with the financial support from the Union Ministry of Agriculture, has received the "Special Mention Award" from the Computer Society of India for the Year 2003-04. This is a "digital inclusion" programme to foster rural enterprises in India. Now he is busy in implementing "DISNIC-PLAN: An Informatics Blueprint that Covers Villages", with the support of the Union Planning Commission, to facilitate "informatics led development" at the grassroots level in India.