Analysis of use of ICT for Rural Development

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***Abstract*— ICT is an integral part of the development strategy of developed and developing countries both. It is highly capable in bringing about social transformation by providing easy access to people, services, information and other desired technologies. Also it can empower the people by expanding the use of government services. It is highly useful for economic development, job-creation, rural development and poverty alleviation. ICT helps n improving living standards in rural areas by providing important social, educational, economic and health benefits. In a developing nation like India, the role of ICT in overall development becomes more important. It can contribute in almost every area such as human rights protection, health, environment protection, education and agriculture etc. Specially in rural context, it acts as an intermediary between the government and the people. ICT had a major contribution in transforming the public sector units in India during mid 90's. ICT improved civil society participation in the governing process, which is also known as e-governance which opens new ways of participation of citizens and communities. It empowers than to develop their self sufficiency. Looking at the high population and higher incidence of poverty in rural India, implementation of ICT & e-governance to cover 135 million people is a very tough task. As of now, there are more than 50 projects using ICT technology for developing India, but since no systematic study or evaluation has been conducted to access these ICT based projects so opportunities to learn the diverse creative Indian experience so far remains entirely wasted. Also existing e-governance models are more technology centric & have been adopted from the west. So they do not ensure complete rural development in a developing country like India. There are several gaps found in the execution of the ICT projects for rural India, where the larger goal of empowerment, digital and preservation of traditional technologies are lot considered. Therefore, taking in view of such limitations it is an important task to propose some alternative approaches to rural ICT projects.**

***Keywords*— ICT , Rural, Development, Strategy , Analysis of use of ICT.**

I. INTRODUCTION

There has been a recent surge of literature on the so-called _digital divide' between developed and developing countries (Bridges, 2001; UNDP, 2001; World Bank, 1999; TDG, 2000; UN, 20001). It is argued that the failure of the South to harness the benefits of the ongoing technological revolution in the North, places developing country populations at an ever increasing disadvantage in globalizing world (Bridges, 2001). While such generalised debate is useful in drawing attention to some of the major issues, the development challenges it presents can appear overwhelming. Furthermore, rather than highlighting priority areas for intervention, such facts and figures tend to obscure and oversimplify complex and long- standing development concerns. The aim here is to try and get beyond the hyperbole that surrounds the digital divide and examine some of the issues and implications from a rural development perspective.

The particular focus of this paper is information and communication technologies. There is a substantial body of literature on the potential role of new technologies in development and the fundamentals of these debates are well rehearsed. Transfer of technology debates have always been polarised between techno-optimists and techno-pessimists. However, while the former certainly often underestimate the complexity of development problems, the latter equally underestimate the flexibility of some of the technologies now available. Current debates on the potential role of ICTs tend to be constrained by an inherent mutual lack of understanding between the technology drivers and development agencies that find it difficult to establish common ground, especially when the technology and its implications for society are changing so rapidly. This apparent impasse raises some particular problems for development research, ICT applications in developing countries remain largely uninformed by recent developments in the wider development literature, and conversely many development agencies have failed to effectively mainstream strategies to harness the potential of ICTs. The specific concern here is the potential role and importance of ICTs in support of rural development. Current ICT initiatives tend to focus on infrastructure development and the extension of information and communication services from the centre to the periphery . However, visions of a network age of integrated information systems on a global scale seem far removed from the reality of rural areas in most developing countries which are far from becoming fully integrated in _global information networks'. Instead the focus of this paper is on the potential for more strategic application of emerging ICTs to address the immediate challenges facing rural areas. In particular how far ICTs offer any new solutions to long-standing rural development problems and whether they can make a significant contribution to enhancing existing and ongoing initiatives. The context of rural development has changed rapidly in recent years but some three-quarters of the world's poor still live in rural areas. Furthermore, although in

decline, agriculture remains the direct and indirect base for the economic livelihoods of the majority of the world's population (IFAD, 2001). There is an extensive literature on the costs/benefits of recent changes for rural areas .Narratives of change range from extreme optimism to extreme pessimism, while on the one hand processes of globalization imply potential increased growth, opportunities and income, on the other they imply potential increased inequality, risk, vulnerability and social instability. Managing processes of transition in rural areas to ensure these risks are minimized and potential benefits maximized, represents a huge challenge for rural development. It is clear however those successful future strategies must be characterized by greater flexibility and adaptability than those of the past (Ellis and Biggs, 2001). International donor consensus on poverty reduction objectives belies the complexity of the challenges facing rural development. The central importance of agricultural growth in reducing rural poverty is well established (Irz et al., 2001) but important debates remain as to how best to _create conditions of growth'. In particular establishing appropriate levels of public and private investment and achieving the right balance between market and public interest. Agricultural liberalization continues apace but private sector alternatives have been slow to develop in many rural areas and donors are placing growing emphasis on the need for more sustainable, democratic and equitable growth (DFID, 2000; World Bank, 2001). In policy advice and dissemination this translates into a concern to harness private sector development towards poverty reduction objectives, e.g. more effective delivery of rural services, and provide social protection for marginalized and vulnerable groups. Further, it is increasingly recognized that, rather than running counter to market interests, the provision of basic public goods (social and environmental) can enhance market development. The need to _make markets work for the poor' has led to a focus on building institutions to support markets and manage growth more effectively. In particular through improving market access for poor farmers, mitigating and managing market related risk and realizing the comparative advantage of different parts of the rural/agricultural sector. Current emphasis on institutional reform is part of a broader, central, agenda of good governance, which encourages greater transparency, accountability and administrative efficiency based upon principles of participation and democracy. In rural areas this frequently manifests itself in programmes for democratic decentralization. The following sections outline the potential role and importance of ICTs in relation to some of the rural development challenges outlined above, in particular the shift to participatory approaches in rural development, and recent emphasis on good governance and democratic decentralization. The importance of ICT infrastructure development for economic growth is well established but what is the potential for more strategic ICT interventions to promote social development goals and help address equity concerns? While it is important to understand the complexity of the rural development context, and that ICTs are no _magic bullet', it is equally important to appreciate the flexibility of some of these technologies to accommodate the specific demands of developing countries. It is only by combining an in-depth understanding of rural development issues, with improved understanding of the capabilities of ICTs, that donors can develop a more balanced assessment of the potential of ICTs to support rural development strategies.

II. DEFINITION OF ICT

Definition of Information and Communication Technologies (ICTs) : ICTs are those technologies that can be used to interlink information technology devices such as personal computers with communication technologies such as telephones and their telecommunication networks. The PC and laptop with e-mail and Internet provides the best example. Michiels and Van Crowder (2001) have defined ICTs _as a range of electronic technologies which when converged in new configurations are flexible, adaptable, enabling and capable of transforming organisations and redefining social relations'. The range of technologies is increasing all the time and _there is a convergence between the new technologies and conventional media' (Michiels and Van Crowder, 2001:8). This rapid and ongoing convergence means that devices such as digital cameras, digital video cameras and players, personal digital assistants, slide projectors and mobile telephones are also compatible with more traditional media such as radio (digital, satellite), television (cable, digital, satellite). Thus most devices can now be linked to others to share and exchange information and allow it to be used in such a way that they can also be categorised as ICTs. Even books are being incorporated into ICTs either through the potential for informal web publishing or more formal digital book publishing with designated readers or _e-books'. ICTs, therefore, are an expanding assembly of technologies that can be used to collect, store and share information between people using multiple devices and multiple media.

III. ICTS IN RURAL AREAS

This section examines the role and importance of ICTs in relation to current and emerging rural development strategies. While the assertion that information is an important focus for future rural development strategies is not particularly contentious, defining the role that information should play is somewhat more challenging. It is not only a question of whose reality (Chambers, 1997) the information reflects but who is able to make use of that information and for what purpose? In the rural development context high priority is often given to information for policy makers, with other _decision makers' a close second. Definition of the term decision makers' is left very open depending on the context of the discussion but all too often systems for information and communication fail to serve the needs of the poorest groups. Frequently, information is seen as useful to government, development agencies, service providers and for process monitoring and evaluation (Baumann, 19992). In discussing the role of ICTs, therefore, we are immediately restricted by a preconception of the role of information in development processes which

forces considerations such as quality, delivery and efficiency to take precedence over flexibility, creativity and usability. In short, a narrow focus on the role of information leads to a more limited perception of the potential role of ICTs. Communication specialists by contrast recognize the potential of ICTs to support and enhance communication across a broad spectrum of actors and activities through the integration of a multimedia mechanism into daily processes.

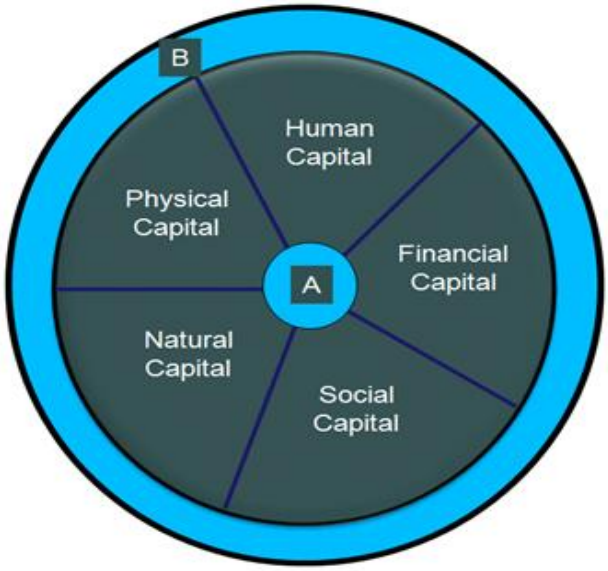

Figure 1 Livelihood Information Wheel

• A is the core information that contributes to long-term capacity building for decisionmaking for appropriate livelihood strategies, usually through education and training, and technical support and assistance with problem solving.

• B is the information that relates predominantly to the local context and needs updating regularly for people to make short term decisions regarding their immediate livelihood activities. It can also contribute to medium-term diversification and livelihood strategies.

According to Ramirez (1998:38) _Communication for development is about aiding different types of actors interested in understanding needs and assessing opportunities jointly; it is about providing them with the methods and media to reach common meaning, and about enabling them to negotiate with other actors with contrasting perceptions and interests'. The focus on the user that is prevalent in communication for development provides a useful basis for broadening the perception of the role of ICTs beyond improving the efficiency of information systems to deliver information from centralized sources and collecting better quality data for centralized analysis. Information and communication activities are a fundamental element of any rural development activity.

Rural areas are often characterized as information- poor and information provision has always been a central component of rural development initiatives. The rural poor typically lack access to information vital to their lives and livelihoods. Building upon the concept of knowledge gaps and information problems, a typology is proposed in figure 1 of information used by the rural poor to prioritise their livelihood activities and investment decisions more effectively.

IV. STATISTICAL SYSTEMS FOR RURAL AREAS

Evolution of the Agricultural Statistics System:

Collection of agricultural statistics in India has long been done by village level officials over most of the country except in the states under the permanent settlement system. In the pre Independence era, when land taxes were the principal source of governments' tax revenue, these officials were mostly permanent, and prominent residents of the village with firsthand knowledge of farmers and farming in their localities. The revenue departments of the provincial governments had put in place a system of standardized format for recording land use and cropping information and periodic inspections by higher level officials to make sure that the records were complete and accurate. The primary purpose of the system was to ensure proper assessment of land taxes – then the dominant source of government revenue. The government also depended heavily on these village records and the village officials'_eye assessment' of the state of harvest for assessing production changes from year to year around estimates of normal yield' made at the time of revenue settlements. These estimates, based on impressionistic judgment rather than systematic measurement of actual yields, were necessarily very rough but adequate to keep track of the impact of droughts and other natural calamities that called for alleviation measures by the state.

The situation changed dramatically in the post independence era when government policy sought to achieve rapid agricultural growth as part of its overall strategy to promote economic development. As the government's role in Formulating and monitoring development programmes and formulating policies regarding pricing, distribution and foreign trade of farm products that constitute the bulk of consumption for most of the population became critical, the need for a system that would provide reliable and timely data on agricultural trends increased. In the early 40s, statisticians in the Indian Statistical Institute and in government had begun to explore ways to build such a system. A systematic survey in a sample of villages to verify the accuracy of the traditional system of gathering land use and cropping through independent field verification found the patwari system to be reasonably reliable. However, since then the system has deteriorated progressively as the interest of State Revenue Departments for proper compilation of village level data and in following the prescribed supervision and inspection procedures declined with the expansion in the nature, scope and range of their functions. This led to the adoption of

sample survey techniques for estimating land use and cropping data at the state and national levels.

It was also clear that the _annawari' estimate of yield could not meet the needs of planning and development. Professor Mahalanobis' path breaking work in the forties had shown that yields of individual crops could be estimated accurately and economically using statistical sampling techniques. This was followed by extensive work in the Indian Statistical Institute on technical aspects of design and conduct of large scale sample surveys to generate reliable data on various aspects of agriculture. The National Sample Survey (NSS), set up as part of Indian Statistical Institute (ISI), was entrusted with the task of conducting integrated sample surveys of land use, cropping and yields.

Around the same time, Statistical Wing of the Indian Council of Agriculture Research (ICAR) which subsequently became Indian Agriculture Statistics Research Institute (IASRI), led by Dr PV Sukhatme and Dr V G Panse experimented with crop cutting on randomly sampled plots for estimation of crop yield rates. But they recommended complete enumeration of land use and cultivation for estimation of crop acreages by the revenue agency. The ICAR adopted their approach and over the next few years area estimation based on complete enumeration was extended to cover the major portion of area under food grains in almost the whole of India; and sample crop cutting was used for yield estimation of wheat and rice. This came to be the basis for official estimates.

While National Sample Survey demonstrated the feasibility of using sample surveys as a technique, the differences between its estimates and those generated by the conventional methods used by state governments were a matter of wide debate. States were opposed to leaving the responsibility entirely to a central agency like the NSS. There were also controversies over differences in estimates based on different designs and methods of conducting crop cutting experiments. Careful scrutiny of the data by experts showed that, provided the sampling design is statistically sound and experiments and procedures are observed meticulously, different designs and the shape and size of plots chosen for experiments will have little impact on yield estimates.

Eventually the integrated land use and cropping surveys by NSS were given up. NSS itself was taken over and made an autonomous organisation (NSSO) of the Central Government. The entire responsibility for collecting the agricultural data was given to the state governments, which continued to use the traditional patwari system. The scope of crop cutting surveys for estimating yields was however progressively expanded. Earlier experience of NSS and extensive research of experts (in ISI and NSSO) specializing in agricultural sample surveys were used to evolve a common design and methodology for use by all state governments for crop yield estimation. The responsibility for implementing sample surveys for yield estimation through General Crop Estimation Surveys (GCES) was also vested with the states.

However, failure to address the weaknesses of mechanisms for collecting and verifying data at the village level, compounded by inadequate attention given by state governments to take corrective measures, eroded the ability of the system to provide reasonably complete, reliable and timely data on crop area and yields. This led to the introduction of the present system consisting of the Timely Reporting Scheme (TRS)/ Establishment of an Agency for Reporting Area Statistics (EARAS) for area estimation and a revamping of the crop cutting surveys in a 20% rotating sample of villages. It also provided for a centrally funded Improvement of Crop Statistics (ICS) scheme through which the primary data collection and conduct of GCES would be supervised and verified by special staff in an independent sample of some 10 farms of a village and 3000 experiments.

V. SUGGESTIONS FOR IMPLIMENTATION

India's current agricultural statistics system relies on village Talathi's / patwaris /Gidwari's to compile plot wise data on land use and crop-wise area and estimates of crop yields based on crop cutting experiments in statistically selected sample villages and plots. That the system is not providing comprehensive, reliable, and timely data on crop area and production has been highlighted in numerous academic forums, conferences and reports of official committees. So are apprehensions that its performance in all these respects has deteriorated. The latest review by the National Statistics Commission provides a comprehensive assessment of the nature of deficiencies in the organization and functioning of the system. They have emphasized the need for reforms to improve the existing system, upgrade the status and professionalism of state statistical organizations and explore the possibilities of using remote sensing.

Following this suggestion, (1) review current methodology used in TRS/ EARAS/ ICS and GCES for estimating land use, crop area, yield and production estimates and suggest institutional framework for improvement of agricultural statistics; and (2) review experience of RS technology for estimating area and yield of various crops, assess its potential for generating reliable and timely data and suggest measures to effectively exploit this potential.

Deficiencies of the Existing System: Detailed analysis of supervision reports of land use and crop area records maintained by patwaris and yield estimates from CCEs under the ICS scheme clearly shows that the system does not deliver complete, timely and reliable data. A special survey of 102 villages showed that areas under different crops grown on sample plots as recorded by FOD supervisors in ICS villages (and village khasra Report of the Expert Committee for Improving Agricultural Statistics in non ICS villages) are at considerable variance compared to information obtained from farmers on the crops they actually grew on these plots in that year.

The deficiencies in the current system of both area and yield estimation are not due to deficiencies in its design. The selection of sample villages for collecting data on land use and crop area, sampling of plots for crop cutting experiments are based on rigorous and statistically sound principles. The procedures for collection, recording, reporting and supervision of the data have been worked out with considerable care. Properly implemented, the system should generate estimates at the state and central levels within an acceptable margin of statistical (sampling) error.

That it has failed to do so is partly due to the scale of effort involved : area estimates require complete enumeration of plots in 120000 villages by exclusive reliance on a large number of poorly trained, over burdened, and poorly supervised village officials. Fragmentation of responsibilities for data compilation, supervision and validation among different organizations working more or less independently has compounded the problem. Indiscriminate increase in the number of crop cutting experiments to generate yield estimates at district and sub district levels has made it very difficult to ensure that they are done properly and without any bias.

Restructuring the existing system: A radical restructuring of the system is necessary to ensure objective, reliable and timely estimates of crop wise area and yields. Changing the present arrangements for collection of primary data in all villages is a huge and difficult task. It needs to be tackled in a phased manner by training of village level functionaries and stricter supervision of their work by the state statistical organizations.

The immediate focus should be on putting in place an institutional arrangement that would provide reliable and timely data needed for monitoring Report of the Expert Committee for Improving Agricultural Statistics agricultural trends and for policy making at the state and national levels. This objective can be achieved by properly designed and carefully monitored collection of data on land use and crop area based on complete enumeration and crop yields based on crop cutting experiments on a smaller scale. On a rough estimate, a sample of 15000 villages (compared to the 120,000 covered under TRS) and 90000 CCEs (as against the planned 170,000 experiments and 880,000 actually done at present) would be adequate to generate reliable state and national level estimates. The personnel required to canvas data and ensuring effective control over data quality through strict supervision of their work will be of manageable proportions and at affordable cost. But it is essential that all the operations involved be planned, managed and supervised by a unified, autonomous and professionally managed organization. For this purpose we recommend setting up of a National Crop Statistics Centre (NCSC) as an autonomous, professional organization in the Ministry of Agriculture of the Government of India.

The NCSC should have a governing body chaired by a person of high professional standing with first-hand experience in design, organisation and conduct of sample surveys of agriculture and include experts in sample surveys and image analysis, senior officials of DE&S and representatives of state statistical agencies. Executive head of the Centre should be a qualified Statistician with experience in conduct of sample surveys.

Primary data on land use in sample villages to be collected by complete enumeration and conduct of sample crop cutting experiments will be done by State statistical agencies enabled and empowered to function as autonomous and professional organizations. The staff they need for this purpose and for supervising them should be dedicated to this scheme with the costs being funded entirely by the NCSC. In addition NCSC inspectors will supervise the conduct of village level workers in a sub sample of the selected villages to verify accuracy of the data collected. NCSC will be responsible for ensuring that deficiencies in the working of field agencies are corrected.

Reliable village level data on land use and crop area are necessary for micro level planning and policy by state and local governments. The present system of recording these data must continue but steps must be taken to bring the responsibility for collection and supervision under State statistical agencies empowered to function as autonomous professionally managed organizations independent of administrative departments. The central government should support and encourage states to undertake these reforms.

Role of Remote Sensing: The advent of satellites has opened the possibility of using remote sensing for estimating land use, crop area and yield. Its technical feasibility has been explored and demonstrated by studies of the National Remote Sensing agency. Its capability is increasing with technological advances in satellite design and sensors. RS also could greatly reduce dependence on human agency and attendant errors in collecting data. Recognizing this, the Ministry of Agriculture has been working with ISRO since 1987 leading to the launch of the project, in 2002, for Forecasting Agricultural Output Using Space, Agro-meteorology and Land based observations (FASAL).

VI. CONCLUSION

FASAL has developed and used methodology for estimating area under different land uses and crops. It provides the Ministry advance estimates of area of major crops at the national state, and in some cases, district levels. Our review: highlights the fact that the feasible level of crop and spatial detail, as well accuracy of estimates, is limited by the capability of satellites and sensors currently in use; that the current methods of validation of RS estimates, or for that matter estimates from conventional methods, are inadequate; and that not much progress has been made in using RS to estimate crop yields. Our pilot study in selected villages to explore the use of RS to track land use and cropping at the village level shows the limited capacity of LISS III for this purpose. However, the advent of higher resolution satellites makes it possible to get more accurate and detailed data on

land use, crops and crop down at all levels down to the village.

The present RS programme should be expanded and reorganized to provide reliable and validated in-season forecasts and end-season estimates of area for a wider range of crops at the state and national levels; as well as comprehensive and detailed plot level data of land use and crops at the village level. It must be complementary to, rather than a substitute for, improving conventional methods of collecting these data. The availability of independent estimates of these aspects from the two approaches for common spatial units and validated by independent verification of actual conditions on the ground, will help assess their reliability with greater confidence. As the capacity of RS to generate reliable and spatially disaggregated data is established, we could consider using it to reduce dependence on the human agency for collecting primary village level data. Considerable amount of work on methodology, estimation and validation needs to be done for establishing the capability of RS to provide reliable estimates of yield. The future programme of RS research to develop appropriate models and test their efficacy using data from controlled experiments in ICAR research stations and Agricultural universities. This has to be planned and implemented as a coordinated programme involving RS experts, and agricultural research institutions. In the meanwhile, the possibilities should be explored for using high resolution imagery to help in sampling design, and improve the conduct of crop cutting experiments by providing more reliable information on the harvest readiness of crops in sample plots.

For crops that cannot be covered by RS, and those (like vegetables, fruits, and cotton) that are harvested, a different approach needs to be adopted for getting detailed estimates of both area and yield (based on stratified sampling of territorial units, and using a combination of sample surveys of households growing them to assess quantities harvested)

Programmes to exploit these potentials have to be based on careful planning of appropriate satellite configurations and sensors to provide them at reasonable cost; improve, test and validate the methodology and protocols for estimation in the light of changing technology; and set up an organizational to implement programme in a professional.

Hardware support: These programmes will need careful planning of the configurations of hardware facilities taking advantage of technological advances in imaging technology as well as sensors that local officials can use for recording plot level land use, irrigation and crops. Satellites are now equipped with both LISS III and LISS IV cameras. While LISS IV has a much higher resolution, its swath and repetivity are much smaller. In order to substantially improve the possibility of obtaining cloud free imagery with optical cameras, more than one satellite, in a similar sun synchronous orbit but displaced from each other to repetitively image same areas at shortest intervals of time is needed.

The appropriate configuration of the satellites and sensors has to be decided after careful review of the requirements (in terms of scope, periodicity, level of detail and precision) of the user (Ministry of Agriculture). The Committee has suggested a minimal configuration of three identical remote sensing satellites, each carrying WIFs, LISS- III, LISS-IV and a C-Band microwave synthetic aperture radar, imaging from the same sun synchronous orbital altitude but displaced by 6-8 days apart in their equatorial crossing longitude. While WIFs and LISS-III are ideally suited to collect relevant agricultural data at state and national levels, LISSIV will be helpful in collecting data at district and village levels. The availability of microwave sensor data will ensure capability of imaging even under heavy cloud conditions.

Hand held sensors (GPS) are now available with the capability to identify lat-long coordinates, and the nature of, and the area under, land use, irrigation status and crops grown on each plot in the cadastral map. They can greatly reduce the effort required to collect the basic data at the village level, improve its accuracy and get them transmitted to a central data network. We recommend that such sensors should be used for village level data collection.

Organisational Aspects: The proposed NCSC should be the nodal agency to undertake the above activities in collaboration with the Departments of Agriculture and Space. Its primary and continuing responsibility will be to provide reliable and timely estimates, at the state and national levels of area under major crops through complete enumeration of plots in selected sample villages and of crop yields based on properly conducted crop cutting experiments. The suggested composition of the governing council and the professional staff is meant to ensure that these are done professionally and in a transparent and objective manner.

The RS unit which will be an integral part of the NCSC will work under the guidance of its governing council. It should provide independent estimates of land use and crop area in the villages selected for NCSC‘s field survey for a rigorous comparison of RS estimates with estimates based on plot wise data collected in these villages. In addition it should be responsible for developing improved techniques of image analysis and validation; arranging for training of personnel in the state and regional remote sensing centres; providing technical advice and analysis needed for informed decisions on the design of satellites and hardware to meet the data needs of users at affordable cost; and help in planning strategies for expanding the scope and scale of RS techniques. In all these activities, the unit is expected to function under the overall policy guidance of the NCSC governing council and work in close collaboration with the Ministry, NRSA and agricultural research organizations.

Reorganizing DE&S: While implementation of our recommendations will contribute to improving the scope and quality of data on key agricultural data, their effective use for better understanding of emerging trends and their underlying causes and for policy advice depends crucially on building the

analytical capacity in the Ministry. The present organization and staffing of DE&S is inadequate and measures to address this inadequacy need urgent attention.

REFERENCES

[1]. Akakpo, J. and Fontaine, M. (2001) _Ghana's Community Learning Centres.' In Latchem, C. and Walker, D. (eds) (2001) Perspectives on Distance Education. Case Studies and Key Issues. Vancouver: Commonwealth of Learning.

[2]. Ashley, C. and Carney, D. (1999) Sustainable Livelihoods: Lessons from Early Experience. London: Department for International Development.

[3]. Ashley, C. and S. Maxwell (2001) (eds) Rethinking Rural Development. Development Policy Review 19 (4) 395–573.

[4]. Baumann, P. (1999) _Information and Power: Implications for Process Monitoring. A Review of the Literature.' ODI Working Paper 120. London: Overseas Development Institute.

[5]. Bridges.org (2001) Spanning the Digital Divide: Understanding and Tackling the Issues. www.bridges.org/spanning/report.html

[6]. Chambers, R. (1997) Whose Reality Counts? Putting the Last First. London: Intermediate Technology.

[7]. Report of the Expert Committee for Improving Agricultural Statistics, Govt of India , 2011.

[8]. Chapman, R., Slaymaker, T., and Young. J. (forthcoming) The Role of Information in Support of Sustainable Livelihoods. Report prepared for FAO, Rome. Christoplos, I., Farrington, J. and Kidd, A. (2001) _Extension, Poverty and Vulnerability.

[9]. DFID (2000) _DFID Target Strategy Paper: Halving World Poverty by 2015.' London: Department for International Development.

[10]. [DOTForce (2001) Global Bridges, Digital Opportunities. Draft report of the G8's Digital Opportunities Taskforce (DOTForce) Consultations, April 2001.

[11]. Ellis, F. and Biggs, S. (2001) _Evolving Themes in Rural Development 1950s–2000s.' Development Policy Review, 19 (4): 437–449.

[12]. FAO (1998) Communication for Development Report 1996–1997. Communication for Development Group. Extension, Education and Communication Service. Research, Extension and Training Division. Sustainable Development Department. Rome: FAO.

[13]. FAO/World Bank (2000) Agricultural Knowledge and Information Systems: Strategic Vision and Principles. Rome: FAO/World Bank.

[14]. FAO/WAICENT/SDR (2000a) FarmNet Farmer Information Network for Agricultural and Rural Development. Research, Extension and Training Division (SDR), WAICENT. Rome: FAO. FAO/WAICENT/SDR (2000b) VERCON Virtual Extension, Research and Communication Network. Research, Extension and Training Division (SDR), WAICENT. Rome: FAO.

[15]. IFAD (2001) Rural Poverty Report 2001: The Challenge of Ending Rural Poverty. International Fund for Agricultural Development. Oxford: Oxford University Press.

[16]. Irz, X., Lin, L. Thirtle, C. and Wiggins, S. (2001), _Agricultural Productivity Growth and Poverty

[17]. Alleviation', Development Policy Review, 19 (4): 449–67.

[18]. ISG and TDG (2000) Internet Use and Diagnostic Study – East Africa (supporting innovation in the

[19]. Provision of agricultural support services through Linked Local Learning). A collaborative

[20]. Project of the International Support Group, Netherlands and TeleCommons Development Group, Canada.

[21]. Jafri, A., Dongre, A., Tripathi, V., Aggrawal, A., Shrivastava, S. (2002)_Information Communication Technologies and Governance: The Gyandoot Experiment in Dhar District of Madhya Pradesh, India.' ODI Working Paper 160. London: ODI.

[22]. Ramirez, R. (1998) _Communication: A Meeting Ground for Sustainable Development' in Richardson, D. and Paisley, L. (1998) The First Mile of Connectivity. Advancing

[23]. Telecommunications for Rural Development Through a Participatory Communication Approach. Rome: FAO.

[24]. Rivera, W. (2001) _Agricultural and Rural Extension: Options for Reform.' In collaboration with Extension, Education and communication Service, SDRE, FAO, Rome.

[25]. Richardson, D. and Paisley, L. (1998) The First Mile of Connectivity. Advancing Telecommunications for Rural Development Through a Participatory Communication Approach. Rome: FAO.

[26]. Richardson, D. (1997) The Internet and Rural and Agricultural Development: An Integrated Approach. Paper prepared for the FAO. TeleCommons Development Group, Ontario, Canada.

[27]. Roling, N. (1988) Extension Science: Information Systems in Agricultural Development. Cambridge: Cambridge University Press.

[28]. [Roling, N (1995) What to Think of Extension? A Comparison of Three Models of Extension Practice. AERDD Bulletin.

[29]. Skuse, A. (2001) _Information Communication Technologies, Poverty and Empowerment.' Dissemination Note 3, Social Development Department, Department for International Development, London, UK.

[30]. M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, ―High resolution fiber distributed measurements with coherent OFDR,‖ in Proc. ECOC'00, 2000, paper 11.3.4, p. 109.

[31]. R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, ―High-speed digital- to-RF converter,‖ U.S. Patent 5 668 842, Sept. 16, 1997.

[32]. (2002) The IEEE website. [Online]. Available: http://www.ieee.org/

[33]. M. Shell. (2002) IEEEtran homepage on CTAN. [Online]. Available: http://www.ctan.org/tex-archive/macros/latex/contrib/supported/IEEEtran/

[34]. FLEXChip Signal Processor (MC68175/D), Motorola, 1996.

[35]. PDCA12-70 data sheet,‖ Opto Speed SA, Mezzovico, Switzerland.

[36]. A. Karnik, ―Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP,‖ M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999