Integrating geo-spatial information technologies and participatory methods in agricultural development

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Sustainable agricultural productivity over the long term was not a major issue in the 1960s and 1970s, as food resources did not appear to be threatened[1]. The attention was on producing enough food to overcome the immediate problems of food deficit. But the environmental effects of intensive agriculture, such as soil erosion and Stalinization, pollution of groundwater and surface water, and loss of biodiversity, have led to the concerns of sustainability of agricultural production and it became a burning issue, on both the global and national scale[2]. The challenge for agricultural research systems' management in the 21st century is to enable the transition to sustainable agricultural development through functional integration of the sustainability concept into agricultural research policies, programmes and projects. The definition of sustainable development given by the United World Commission on Environment and Development (1987), commonly known as the 'Brundtland Commission', can be adopted as the starting point: 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. The sustainable concept, therefore, has physical, ecological, social, cultural and ethical dimensions. Sustainable agriculture involves efficient and effective management of environmental, economic and social aspects. Moreover, it involves dynamic interactions between technology, environment and society[3,4]. Generally, Geographical Information System (GIS) is being used as a decision support system by policy makers, scientists and administrators. However, implementation of GIS technologies at the village level and empowering the farmers to use them for local-level planning and monitoring agriculture for its sustainability is lacking.

Geo-Spatial information technologies

GIS has proved to be an efficient and effective tool for spatial analysis and management of natural resources. GIS is a specialized branch of geo-spatial information technology that helps store, manage and analyse geographical reference data. Devices that measure geographic location such as global positioning system (GPS), provide data on location in terms of latitude, longitude and altitude required for the GIS. Airborne data collection systems through remote sensing (RS) technologies, such as aerial photographs and satellite remote sensing provide periodic land use, land cover and other thematic information[5]. GIS, GPS and image processing software systems for processing RS data, form the basic components of the geo-spatial information technology. GIS is also a tool that integrates statistics with geographic location to derive meaningful and informative maps, graphs and tables that can be used for better decisions to meet at different scales. Technologies like RS and GIS basically follow top-down approaches. As use of technology needs considerable level of expertise, it is generally confined to scientists, experts, and laboratories. These geo-spatial technologies are the foundations for precision farming (PF), a paradigm shift in agriculture[6,7]. The concept of PF is based on decisions on optimum use of inputs based on variability of soil, crop, weed, pest, etc. – factors at the field level. Geo-spatial technologies are the basis for developing decision support systems based on variability of crops, soils and other factors. Being projected as decision support systems, now these technologies are making inroads and gaining popularity among decision-makers and policy professionals. Interactive community maps could be a modest beginning.

Participatory methods

Participatory methods are developed mainly to address the sustainable livelihoods approach. A set of diagramming and visual techniques originally developed for livelihoods analysis is now widely used by natural resources development agencies. Participatory methods have the potential to bring together information from a diversity of sources more rapidly and cost-effectively, than quantitative or qualitative methods. Participatory methods are not a fixed set of mechanistic tools, but a diverse range of possible techniques which need to be flexibly adapted to particular situations and needs. In some cases problems can be resolved through innovation in the methods themselves. The emphasis is on innovation and creativity in adapting old practices to new contexts and needs. Quantitative techniques are frequently inadequate to understand causal processes and many qualitative techniques conducted at the individual level are limited in their coverage. Participatory methods are useful for investigating development processes and complex interactions between grassroots perceptions and strategies, institutions and interventions. Participatory methods cannot be seen as a cheap option. They must be treated as a serious and integral part of monitoring and assessment of agriculture and rural livelihoods for their sustainability.

Participatory research allows researchers to gain a better understanding of the role of technology in complex systems. Participatory research approaches can contribute to developing more appropriate technologies to suit different environments and socio-economic conditions by incorporating the farmers' own analysis of the technology in relation to their own livelihoods. Among the participatory approaches, the methodologies of PRA (Participatory Rural Appraisal) are well documented. These are essentially a process of learning about people's conditions in an intensive, iterative and expeditious manner. They characteristically rely on small, interdisciplinary teams that employ a range of methods, tools and techniques, specifically selected to enhance the understanding of people's conditions, with particular emphasis on tapping the knowledge of local inhabitants and combining the knowledge derived from modern, scientific expertise. These techniques are adopted to achieve increased accuracy at low costs, both in terms of time and money. Participatory

appraisals are not mechanical processes of information gathering, where data are stuffed in a box and taken home for analysis. Here information is analysed as it is collected in the field, so that the team's understanding of issues grows throughout the field study.

Participatory GIS

GIS methodologies are merging, that involve not only practitioners of the technology but also the populations who stand to be affected by spatial information products. Emerging concepts include 'community-integrated GIS', which remains agency-driven but incorporates stakeholders' perspectives of their landscape[8], and 'GIS in participatory research', which considers GIS as a tool to be integrated with pre-existing forms of social investigation[9]. An underlying assumption in these definitions is that by participating in the process of GIS application, stakeholders can significantly contribute to the success of resource management efforts[10]. Such strategies for the merging of community development with geospatial technologies for the empowerment of the less privileged communities is known as participatory GIS (P-GIS)[11].

P-GIS will strengthen local-level spatial planning[12]. It is considered to have superior effects in terms of relevance, usefulness, sustainability, empowerment and meeting good governance objectives. Participation is the key and essence to P-GIS. Participation and knowledge of local groups is understood to be a valuable resource in community-level natural resource management, decision making and policy planning.

GIS provides a framework to document and store indigenous knowledge meaningfully[13]. Incorporating indigenous and scientific knowledge means integrating information collected from farmers, with scientific information and technology. That is, we must find a way to process indigenous information as scientific information[14].

GIS for indigenous knowledge management

Indigenous knowledge is the body of knowledge and experiences of a given community, that forms the basis for decision making in the face of familiar and unfamiliar problems and changes. It is a key input for planning and monitoring sustainable development. Indeed, participatory appraisals try to understand issues from the informant's viewpoint instead of always interpreting from an outside perspective. Until now, the possible application of GIS in indigenous knowledge management has been underexplored. Due to the spatial nature of traditional knowledge, GIS can assist in the inclusion of indigenous knowledge in the local decision-making process. Accordingly indigenous knowledge should be recognized as important as are other types of spatial information that are factored into the scientific decision-making process[15]. Many researchers have integrated indigenous knowledge into GIS for various purposes. Though almost all approaches are participatory in nature, the application has differed according to the need and objectives of the study or the community. Gonzalez[16] used participatory approaches for integrating indigenous knowledge into GIS for natural resources management. Puginier[17] used local knowledge in GIS as a communication tool for community-level land-use planning in northern Thailand. Mari and Bitter[18] have used GIS and Rapid Rural Appraisal (RRA) in local-level land-use planning in Sri Lanka. The challenge in building an indigenous knowledge base lies in the understanding and reasoning with the aid of largely abstract, qualitative observations of the local environment. These include heuristic rules that are typically less precise and are sometimes called rules of thumb. Among indigenous peoples and local communities, these rules are passed on from one generation to the next and are gradually refined into a system for understanding the world around them.

As indigenous information is acknowledged to be a valuable input in such exercises, it must be available and accessible at all times. GIS technology makes this possible. It provides both spatial and non-spatial information, which facilitates both planning and decision-making aimed at the sustainable management of natural resources. Another benefit of GIS is the fact that it can narrow the information gap between professionals and resource users by making indigenous information more transparent, understandable and accessible to a wider audience. This is essential for achieving sustainable development.

Conclusion

If the rural GIS through participatory process is well designed, it can lead to the empowerment of local communities and has the potential of being a valuable tool for scaling up local knowledge and concerns to the regional level. The community knowledge can then be incorporated into the regional and national policy. Information technology is identified as the key factor in economic growth. Hence, the Government of India has set up several Village Knowledge Centres (VKC) (http://capart.nic.in/scheme/vrc.pdf) to provide access to a range of services, content and information to people living in the villages. Creating spatial databases on natural and socio-economic resources along with indigenous knowledge through participatory GIS approach may enhance the effectiveness of VKCs for monitoring and management of agriculture towards sustainable rural livelihoods. For the collection of primary data, a number of different data-acquisition techniques are used, such as RRA, PRA Village immersion, farmer-based interview schedule, field visits and observations, use of checklist of questions, analogue maps and aerial photographs. Such integrated techniques of data retrieval have proved efficient in obtaining reliable information from the farmers. Each technique is selected for a particular purpose. But research is needed on the participatory methods themselves to meet the increasing demand of local information and also on integration into GIS.

Researchers, by overlooking the role of indigenous knowledge, have failed to sustain the human–environment relationship in less developed regions. However, it is important to discern what indigenous knowledge is, from where it comes, and how to collect it, store it, and process it in order to aid the decision-making process in agricultural management. Indigenous knowledge has to be recognized as 'local knowledge' that is unique to a given culture and is the information base for a society which facilitates communication and decision-making. GIS-based decision support systems seldom incorporate indigenous knowledge as a factor in agricultural management. In planning and decision-making exercises directed towards sustainable management of agriculture, it is essential that the various types of information relating to a particu-

lar area of concern are available. The combination of indigenous and scientific knowledge promises a greater success in land-use planning. GIS with its analysis, modelling and visualization tools can bring scientific knowledge into participatory local planning exercises. With the GIS model it is possible to prepare an indicative land-use map for a relatively large area with little effort (not accounting for the collection of base data). With the availability of high-resolution satellite remote-sensing data, it is now possible to produce real-time, accurate, land-use maps in a village, which can be the basis for developing participatory GIS. Today, more and more people are recognizing and promoting the importance of indigenous knowledge for the purpose of sustainable development. Such knowledge is a valuable resource and requires proper management. This approach of using GIS in a participatory content maximizes the utility of indigenous information for development, as it has the potential for empowerment of local groups and communities, and at the same time provides a platform that can be shared by many users.

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