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Agricultural information systems and their applications for development of agriculture and rural community, a review study

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Abstract: This review paper presents the background introduction, theories, literature review and analysis of information systems in agriculture. The usefulness of information for agriculture, sources of agricultural information, types of information needs for agricultural development, problems of dissemination of agricultural information are discussed. The study is mainly to identify agricultural information system components, their availability, the understanding of how successfully they work, problems associated with them and how to improve their performances. The review of analysis methods and process of agricultural information systems are also explained. They can also be used to develop suggestions to solve the common problems in agriculture information systems, to improve the policy programs, the extension[1] and research activities, and to manage information on agriculture. Finally, general conclusions about agricultural information systems are emphasized and implications for further development of agriculture information systems are presented.

Key words: Agricultural information systems, Information need of farmers, Agricultural information dissemination

1. Introduction

1.1. Importance and needs of agricultural information systems for agricultural development

Agricultural information is an important factor that interacts with other production factors. Productivity of these other factors, such as land, labor, capital and managerial ability, can arguably be improved by relevant, reliable and useful information. Information supplied by extension[1], research, education and agricultural organizations helps farmers make better decisions. Therefore, there is a need to understand the functioning of a particular agricultural information system in order to manage and improve it (Demiryurek et al., 2008).

According to the findings of Maningas et al. (2000), information within the hands of the farmers means empowerment through control over their resources and decision-making processes. They noted that being an effective and efficient delivery system of essential information and technology services facilitates the clients' critical role in decision-making towards improved agricultural production, processing, trading, and marketing. Food and Agriculture Organization

points out, information is very important for rural development because improving the income of farming community will depend crucially upon raising agricultural productivity. Achieving sustainable agricultural development is less based on material inputs (e.g., seeds and fertilizer) than on the people involved in their use. For achieving this there is a need to focus on human resources for increased knowledge and information sharing about agricultural production, as well as on appropriate communication methodologies, channels and tools.

New agricultural technologies are generated by research institutes, universities, private companies, and by the farmers themselves. Agricultural information and knowledge delivery services (including extension, consultancy, business development and agricultural information services) are expected to disseminate new technologies amongst their clients (people who are involving in agriculture). The role of research and advisory services is to give highly accurate, specific and unbiased technical and management information and advice in direct response to the needs of their clients. Due to poor linkages between research and advisory services, the adoption of new agricultural technologies by farmers is often very slow and research is not focusing on the actual needs of farmers. In many countries low agricultural production has been attributed, among other factors, to poor linkages between Research-Extension-Farmers and to ineffective technology delivery systems, including poor information packaging, inadequate communication systems and poor methodologies. Therefore, the information systems which integrate farmers, agricultural educators, researchers, extensionists and farmers should be introduced for agriculture sector. They operate as facilitators and communicators helping farmers in their decision making and ensuring that appropriate knowledge is implemented in order to obtain the best results in terms of sustainable production and general rural development) and the private sector (support and input services, traders) to harness knowledge and information from various sources for better farming and improved livelihoods (FAO, 2005).

However, this integration among people and institutions, particularly in the research-extension-farmer relationship, has not been successful in many parts of the developing (and developed for that matter) world. There is also a basic difference in the information needs between market-oriented, transitional and subsistence based farming. In addition, recent experiences show that, the human components of the system such as researchers, educators, extensionists and farmers are not connected together in information flow. Therefore, it is a current need to investigate that the proper information delivery systems for agriculture sector and people that are involving in agriculture. However, there have been limited studies about the agricultural information systems. Thus, there is a need for substantial information about these issues, including the mechanisms of the information systems, interactions between components in the system, and their activity. Specifically, the information requirements of farmers, the structure of the organizations involved in these activities are issues that need to be explored (Demiryurek et al., 2008).

The study is to emphasize the importance of agricultural information systems for agricultural development and to identify the strength and weaknesses of the current systems and led to recommendations for improving their performance. This review paper presents initially the definitions and models related for agricultural information system. Then it describes the analysis

of agricultural information systems. Thirdly, the findings of the related previous studies are reviewed. Finally, the general conclusions about agricultural information systems are emphasized and implications for better agriculture information systems are suggested.

2. Definition and model of agricultural information systems

An agricultural information system can be defined as a system, in which agricultural information is generated, transformed, transferred, consolidated, received and fed back in such a manner that these processes function synergistically to underpin knowledge utilization by agricultural producers (Roling, 1988). Accordingly, an agricultural information system consists of components (subsystems), information related processes (generation, transformation, storage, retrieval, integration, diffusion and utilization), system mechanisms (interfaces and networks) and system operations (control and management). Agricultural information is considered as an essential input to agricultural education, research and development and extension activities. Different kinds of information are required by different kinds of users for different purposes. The potential users of agricultural information include government decision-makers, policy-makers, planners, researchers, teachers and students, program managers, field workers and farmers (Zaman, 2002). Figure 1 gives an illustration of the flow of agricultural information.

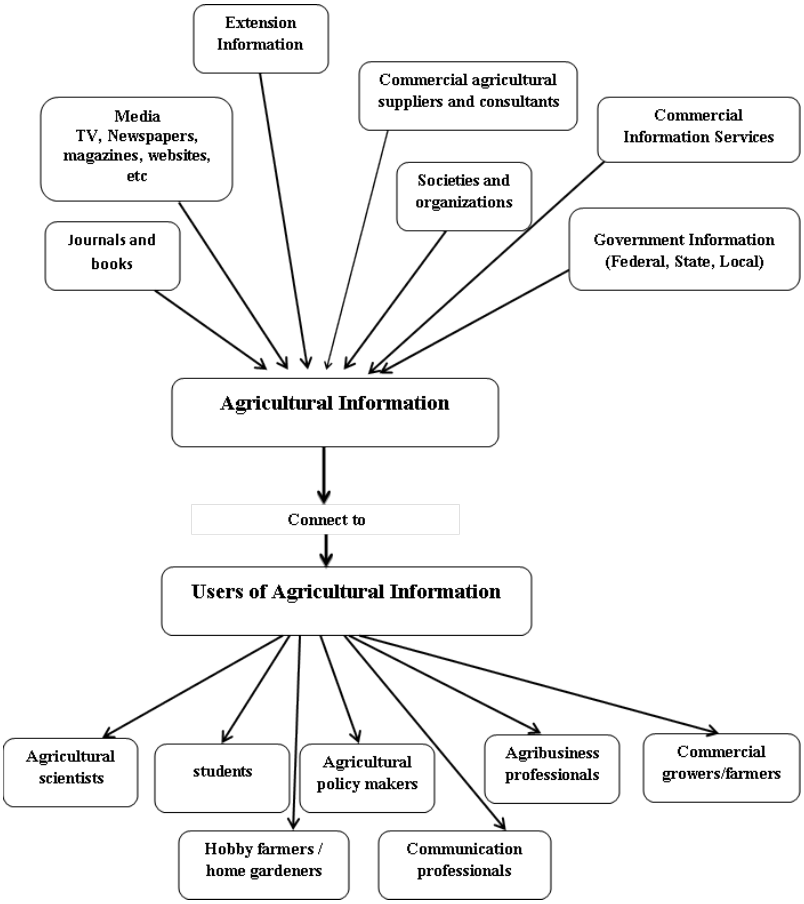

Figure 1: Concept map for agricultural information (Source: McCue et al., 2005:5)

The analysis of the agricultural information system in a specific farming system may provide the identification of basic components and structure of the system, the different sources of information used by different components in the system, the understanding of how successfully the system works and how to improve system performance (system management) (Demiryurek, 2000). This approach is also useful to identify possible defaults and improve the coordination between components (i.e., information management). Rogers (1995) emphasizes that the exchange of information (communication) and its diffusion take place within a social system. Actors such as individuals, informal groups, organizations and subsystems are the members of the system and the structure of the social system and their actors or members' roles affect the diffusion process. When considering the actors farmers and agricultural extension[2] officers are key persons in between information flow.

Some authors criticize the system approach to agricultural information system and especially knowledge dissemination and its ultimate utilization. They defend a different approach, namely an actor-oriented view (Leeuwis, 2004). They emphasize that knowledge and information are the elements of a single process in which information is internalized to become a part of knowledge. Thus, it is difficult to distinguish between knowledge and information. The actor-oriented approach views knowledge processes as social processes which may lead to conflict among social groups or common perceptions and interests. Ramkumar (1995) developed an actor-oriented information system approach which considers the farmers' social, economic and cultural characteristics. This approach helps to understand the complexity of farmers' information systems and their relations with other systems.

3. Previous studies/ Literature review

One of the early studies conducted by Rolls et al. (1994) analyzed the information system for smallholder farmers in Malaysia. They put farmers central to the information system and found their roles as producer, inventor and communicator. There was a considerable information exchange among the actors in the system and the farmers in particular were active in disseminating innovative information and technology.

Similarly, Ramkumar (1995) analyzed the information systems of dairy farmers in two villages of India and found that each farmer's information system was unique. There was little linkage between farmers and non-farmers in and outside the villages. The printed media and the dairy extension workers were rarely used as information sources, but the private veterinarian and the secretary of the milk cooperative were widely used. The farmers functioned as both disseminators and users of information. Decision-making by the farmers was made more complex by inappropriate and inefficient information transfer from research and extension services. This compelled the farmers to capitalize on their working knowledge to find suitable solutions.

On the other hand, Garforth and Usher (1996) reviewed various models of information system processes such as development and transfer. They stressed that these processes showed that information does not simply flow, but is continually being transformed and adapted through communication. Systems models allowed the researchers to move away from unilinear conceptions of information and technology development and dealt more effectively with the diversity of information sources available to potential users.

Ortiz (1997) analyzed an agricultural knowledge and information system and researched the dissemination of integrated pest management related information among research, extension and potato producers in Peru. It was found that potato-related pest management is a technology demanded from farmers. The management of these types of information created for farmers the need to understand the technological principles of integrated pest management. The researcher concluded that information dissemination required to be included within a learning system so that farmers could acquire appropriate knowledge and used it to make decisions in a more flexible way. In addition, the system formation was facilitated by personal and organizational sources with internal and external pressures and between demand for, and supply of, integrated pest management information.

Demiryurek (2000) also used agricultural information system theory to analyze the current information systems used by organic and non-organic hazelnut producers and found that the information systems for the two groups of farmers were largely separate. The conversion to organic production clearly demanded changes in the information system to allow producers to acquire the appropriate new knowledge and skills. The organic producers had used more information sources more frequently and more actively than non-organic producers.

Hoang et al. (2006) explores how social networks function as assets for people and households in the rural areas of developing countries and influence the access to information and the benefits from research and development. They presented a case study of such networks in a village of Northern Vietnam and provided evidence of the need for the efficient delivery of extension services and research and development interventions at the micro level.

Rolls et al. (1999) analyzed the information systems in Czech agriculture. The information systems appeared to be the construct of the personal characteristics of the farmers. The farmers appeared to regard information as a social good to be exchanged and discussed within social networks. Printed materials, agricultural shows, and demonstrations were strong sources of agricultural information, and consultants also gained recognition as valued components of the information system. Rolls and Slavik (2003) also investigated changes in information systems in Czech agriculture over time. The actual sources of information were changed although about half remained the same. Printed media remained most important, social sources decreased in importance, and professional sources, such as consultants, research and university sources, increased. The horizontal transfer of information between similar farms remained very important. The researchers suggested that new information sources related to agriculture are needed and they predicted that computerized databases will be increasingly used in the future.

Naidoo and Rolls (2000) also investigated agricultural information use by small-scale cattle farmers in Mauritius and found that the farmers managed information as a production resource. The personal characteristics and cattle husbandry practices of the farmers were major influences on their management of information. The practices were mainly learnt from family elders. Extension advice was only partly remembered, or rejected as the information from this source was sometimes not useful.

In contrast to the farmers networks analyzed at the micro level by Hoang et al. (2006), Morone et al. (2006) researched information diffusion and social networks in the organic food sector in the province of Foggia, Italy. They found that the organic sector was becoming more complex, presents a challenge for organic farms and firms to overcome these changes. They also studied the role of institutions in diffusing information to the producers and identified the crucial information needs and gaps.

Recently, there have been some studies on the use of the digital information systems and technologies in the agricultural and food sectors. Šilerová and Lang (2006) discussed the usage of the information systems and the expansion of the portals in the rural sector. The development of the information systems and its implementation with the portal solutions enable a web access to the information and the effective management and administration (Šilerová and Kučírková, 2008). Similarly, Kučera and Látečková (2006) pointed out the importance of information systems concerning the solutions by the computer software and the expertise systems in agriculture and food sectors. These systems help to make decision and contribute to the information management. Mistr (2007) also stressed that the future of the information systems will have to be designed as user-friendly computer programs and portals in the agricultural information systems. Dařena (2007) applied the information systems theory to marketing and established marketing information systems to support and manage marketing activities.

Numerous studies have highlighted the short-comings of traditional print- and library-based methods of providing information to rural farmers and rural community who are generally illiterate and relatively remote from formal sources of information (e.g. extension stations, libraries). Scientists of the new information and communication technologies suggest that technology can overcome these barriers by delivering information right and need based to the rural people via new information technologies (Morris, 2000 and Ommani, 2005).

4. Analysis of agricultural information systems

When analyzing agriculture information systems we should look for the sources of information, the content of information, the exchange (both receive and transfer) of information, the extent of the information contact, the degree of usefulness and the reason for not using it, the type of information needed and so on.

4.1. Sources of agricultural information

Information source is an institution or individual that creates or brings about a message (Statrasts, 2004). The characteristics of a good information source are relevance, timelessness, accuracy, cost effectiveness, reliability, usability, exhaustiveness and aggregation level (Statrasts, 2004). According to Oladele (1999), the efficiency of technologies generated and disseminated depends on effective communication which is the key process of information dissemination. The development of agricultural technologies requires among other inputs, a timely and systematic transmission of useful and relevant agricultural information (messages) through relatively well educated technology dissemination (extension) from formal technology generation system (research) via various communication media (channels) to the intended audience – farmers (Oladele, 1999). It is expected that the message from the client (effect) be passed back to the source or research (feedback) for the communication process to be complete. Despite the attempt at technological innovation transfer, the wide gap between the levels of production which research contends is attainable and that which farmers achieve suggests a missing link (Oladele, 1999). Also, weak linkages between the farmer, extension and researcher mean that the farmers are not included in the planning of the innovation and hence do not know where to get their technologies despite the fact that they are the end users. Agricultural information disseminated by different information sources needs to be determined. It is imperative therefore to identify the sources of agricultural information utilized by farmers.

A study by Njuguna and Kooijman (1999) reported that the sources of agriculture information ranked most frequently in the top were neighbors, local meetings and government extension. Farmer training colleges and organized tours were mentioned least frequently. Government agricultural extension[2] staff was mentioned as important information sources by half to three-quarters of respondents, and neighbors and relatives were listed as amongst the most important sources. Non-Governmental Organizations and churches were important sources of information in some divisions. Radio was mentioned as an important medium of agricultural information.

The study by Opara, (2008) investigated the sources of agricultural information available to farmers in Imo State, Nigeria as well as the farmers' preferred sources. The results mentioning that that 88.1 percent of the farmers indicated agricultural extension agents as their source of information, 71.2 percent indicated fellow farmers, 63.2 percent indicated radio, 43.3 percent indicated television, etc. The results further showed that majority (70.0 percent) preferred the extension agent to the other media (radio 28.4 percent, friends and relatives 27.2 percent, television 19.1 percent, etc.) The results emphasize the need for the extension agency to regularly identify those sources of information that farmers prefer, or use most, as this will enable them deliver agricultural information effectively to the farmers.

The study conducted by Rees et al (2000), summarizes the various and varied sources of information quoted by farmers. Community Based Organizations and traders in the sub-location feedback meetings, friends, relatives, neighbors, women's groups and school/youth groups were reported as major sources. Other organizations such as farmer cooperatives were also mentioned

as a significant source. Traders and markets were also mentioned as important sources. Most of farmers considered the Ministry of Agriculture as a major source of information and most also reported getting agricultural information from barazas (local meetings called by the area chiefs – appointees of the Office of the President). Government extension staff was mentioned as important information sources by half to three-quarters of respondents, and neighbors and relatives were listed as amongst the most important sources.

4.2. Types of information received

The study conducted by Rees et al (2000), on agricultural knowledge and information systems (AKIS) undertaken by the Kenya summarizes the types of information obtained by farmers. It is mentioning that technical information was reportedly received by 16–33 percent of farmers. However, most end users felt that information flow for this category was particularly deficient; the major knowledge gap expressed in the feedback meetings in all four districts was for technical information (e.g. how to manage late blight in potatoes, where to get certified seed, the most appropriate varieties for a given location, housing and management of livestock, etc.). Other information types it mentioned are marketing information and operational information.

The findings of Ozowa (1995) indicate that the information needs may be grouped into five headings: agricultural inputs; extension education; agricultural technology; agricultural credit; and marketing. Modern farm inputs are needed to raise small farm productivity. These inputs may include fertilizers, improved variety of seeds and seedlings, feeds, plant protection chemicals, agricultural machinery, and equipment and water. An examination of the factors influencing the adoption and continued use of these inputs will show that information dissemination is a very important factor. It is a factor that requires more attention than it now gets.

4.3. Methods of analyzing agricultural information systems

Limited numbers of studies have discussed the methods for analyzing the agricultural information systems (Röling, 1988). Some studies (Jones et al., 1987; Rolls et al., 1994; Ramkumar, 1995; Ortiz, 1997; Demiryürek, 2000; Boyaci, 2006) had only used the frequency of information contact with various information sources in order to measure the information score. On the other hand, Rolls et al. (1999) and Rolls and Slavik (2003) had separately analyzed the extent of the contact and the degree of the information usefulness. Demiyürek et al. (2008) and Demiryürek (2010) used the Total Information Score (TIS), which is a combined variable of the frequency of contact with information sources and their usefulness. Thus, the TIS reflects not only the quantity but also the quality of the information contact.

Information scores for each component of the information systems can be calculated by multiplying the number of the information contact (weight) with the degree of information usefulness (TIS = number of contact × usefulness of information).

The weights can be given to each component according to the extent of the information contact. A weight of 0 can be given for no contact, 1 for once a year and 2 for two times a year and so on. Similarly, the degree of usefulness of information sources can also be weighted. A weight of 0 can be given to not useful at all, 0.25 for a little useful, 0.50 for somewhat useful, 0.75 for useful and 1.00 for very useful. The scores can be calculated on the basis of the percentages of farmers reporting each level of usefulness for each source.

According to TIS, in order to define the concept of information contact, the respondents can be asked to specify each source of information and the frequency of contact in a specific year. In addition, they can be asked to rate the degree of usefulness for each information source. Instead of asking them to select whether these sources were good or bad, these ratings included multiple choices ranging from not useful to a little useful, somewhat useful and so on. Thus, a frequent contact without useful or relevant information can be eliminated. In addition, the frequency of contact and the degree of usefulness can be correlated to measure the agreement between these two variables. The degree of information contact can also be categorized into different groups according to the information scores of each information source. These items can be classified as weak, moderate and strong degrees of the information contact. This classification can be based on the average and standard deviation of the information scores (Demiryürek, 2010).

These scores can also be compared between different kinds of producers and/or production systems. In addition, the scores can be correlated or compared with the socio-economic characteristics of different groups of farmers and farms. Comparing the socio-economic characteristics of farmers and their farms is essential to develop the appropriate methods to transfer information and analyze the information systems, since the information systems are the construct of the personal characteristics of the farmers (Rolls et al. 1999), and together with the production practices they are major influences on their information management (Naidoo and Rolls, 2000).

5. Problems of agricultural information dissemination

There are some limiting factors and apparent constraints in agricultural information dissemination in many developing countries. One of the obvious constraints in the use of the broadcasting media in many cases in developing countries is poor reception quality and the area covered. The messages carried are not tailored to the information needs of rural populations. Even when the information is relevant, it is seldom aired at the proper time and so does not get to the targeted audience. Another major constraint is the use of print media: leaflets and newsletters as message carriers are of limited use in reaching illiterate farmers. Technical language used in communicating information is incomprehensible to the farmers. Another major constraint to agricultural information dissemination is the inadequacy of existing extension programs[2]. Some of these programs are conceived without well thought out plans and are prepared in a hurry without the farmers whose attitudes are to be changed making any input. Such agricultural information packages can neither sustain the farmers' interest nor effect the desired attitudinal

change. Farmers' interests are disregarded even more as most of the agricultural innovations are written and broadcast in English instead of the local language (FAO, 2005).

There is a lack of smooth flow of information to end-users. An increase in the qualifications of the extension workers would remove some of the obstacles to a smooth flow of information (e.g. communication with the farmer, or coordination with research institutions). There are still problems in the agriculture information systems itself, in terms of planning extension activities, and the agricultural research–extension linkages are very weak. One way to overcome this problem may be to stop the over-differentiation between research and extension institutions (Ozkaya and Olgun, 1993). Extension activities themselves are still planned centrally and the information flow model is, more or less, from top to bottom. Thus, farmer participation in planning extension activities is very weak (Olgun, 1997). Studies of farmers' adoption of new technologies in industrial agriculture have often been framed within the traditional adoption-diffusion model of innovation in which a few innovators initially adopt a conservation technology, then the majority of farmers do so, and finally the remaining laggards join in (Jones, 1963).

Farmer participation is especially valuable, since better communication between scientists and farmers would increase the utility and reliability of information reaching farmers. Research projects must intentionally incorporate farmers as sources of knowledge from the outset, rather than seeing them as passive receivers of information (McCorkle, 1989; Saver, 1990; Kloppenburg, 1991).

In the flow of agricultural information, despite the application of technological transfer approaches, many problems remain unsolved while indeed new ones have appeared in the world as a whole. Technological advances and software packages developed with the hope of promoting efficiency in the information dissemination practices of research institutions and universities, or even in the companies of the developed countries, have not in reality brought benefit to farmers. Moreover, the small size of farms, illiteracy among farmers, the lack of organizational unity among farmers, and the instability of national agricultural policies have all played a part in undermining the effectiveness of the agricultural information delivery. This demonstrates how vital aspects of the agricultural information system have not worked properly, with information failing to reach users in timely or effective fashion (Kizilaslan, 2006).

6. Conclusion and recommendations

For carrying out various activities by farmers and rural areas, among other things, information support is also vital. As discussed in the paper, majority of the rural farmers are not having access most of the required agricultural information. Therefore, application of ICT-based agriculture information support systems is very much important for the dissemination of agricultural information and technological knowhow by rural farming community.

To betterment of information systems in agriculture it is highly recommend to establish communication between farmers, coordinators, agricultural experts, research centers, and

community by information technology. The information must be based on farmers' needs, internet used as a mode to transfer the advanced agricultural information to the farming community. Farmers can be illiterate and speak a local language and they are not expected to use the system directly respectively. So these conditions also should be considered when implementing better information systems for agriculture and rural people.

The analysis of the agricultural information systems may provide the identification of the basic components and networks of the system. It can be applied to any specific farming systems in order to analyze how the information system works. This approach is also useful to define the possible defaults and to improve the information management. In addition, the information exchange (communication) through networks among the system components is critically important for the successful technology generation and information transfers.

The information system analysis indicates that more interactive information sources are needed. This may stimulate conventional farmers to convert to the modern approaches of farming. These changes could have been stimulated by more active experts working with selected local leaders if they had developed and improved relationships with public (especially extension and research) and private information sources. The complexity of the agricultural information system leads to an underestimation among end-users. Lack of knowledge of agricultural information may weaken the support for public information funding as a major priority in agriculture. An increase in funding for public information should allow for an increase in the accessibility of public information to farmers.

For easy access and effective utilization of agricultural information in this digital age, there is need for establishment of information centers. Such information centers would be able to provide the rural farmers the desired agricultural information in a format that would be comprehensible to them, taking into cognizance the prevailing high illiteracy rate, cultural differences and limited technology (Aina, 2007). For effective dissemination of agricultural information in rural communities by extension staff, research institutes and other responsible persons, there is need for construction of good access roads that would lead to all the remote rural communities in the country.

Notes

1. Extension means ‘‘reaching out,’’ and – along with teaching and research–educational institutions will ‘‘extend’’ their resources, solving public needs with resources made available through a variety of outreach programs. Adapted from: United States Department of Agriculture, Cooperative State Research, Education, and Extension Service, available at: http://csrees.usda.gov/qlinks/extension.html
2. Agricultural Extension, broadly defined, focuses on the delivery of information inputs to farmers. Information can be many types, from estimates of future prices for farm products to new research products, such as improved crop cultivars and knowledge about how to use particular inputs (Byerlee, 1998). The goals of agricultural extension include

transferring information from global knowledge base and from research to farmers, enabling them to clarify their own goals and possibilities, educating them on how to make better decisions, and stimulating desirable agricultural development. Extension workers have the task of bringing scientific knowledge to farm families in the farms and homes. The object of the task is to improve the efficiency of agriculture. (Van der Ban and Hawkins, 1996)

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