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Agricultural Extension Systems Toward SDGs 2030: Zero Hunger

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Synonyms

Agricultural advisory services; Agricultural knowledge system; Ecological knowledge system; Participatory extension approach; Technology transfer

Definition

Extension as an advisory process is as old as mankind. Sitting together, discussing, and searching for wise decisions and better solutions is a social activity of typical human character (Hoffmann 2009). Although agricultural extension has roots as far back as 1800 BC, formal extension in most countries did not start until the late 1800s AD. According to Black (2000), there is no commonly agreed definition of extension. Based on van den Ban and Hawkins (1996), ". . . extension involves the conscious use of communication of information to help people form sound opinions and make good decisions." Agricultural extension (also known as agricultural advisory services) refers to a crucial, nonformal educational function that aims to enhance agricultural productivity, increase food security, and improve rural livelihoods by acting as a mechanism for pro-poor economic growth (Rivera and Qamar 2003). This is accomplished by incorporating scientific research and knowledge into agricultural practices through farmer education. Generally, agricultural extension can be defined as the "delivery of information inputs to farmers" (Anderson and Gershon 2007). Marsh and Pannell (1998) define agricultural extension broadly to include ". . . public and private sector activities relating to technology transfer, education, attitude change, human resource development, and dissemination and collection of information." Extension is used to provide rural support services and promote and facilitate development; so, it is critical for meeting new challenges faced by agriculture, e.g., changes in the global food and agricultural system, including the rise of supermarkets and the growing importance of meeting international standards; growth in nonfarm rural employment and agribusiness; constraints arising from climate change; market volatility; the deterioration of the natural resource base change; and other challenges that affect rural livelihoods (Aker 2011). According to Kipkurgat and Tuigong (2015), "Extension is both a political and an organizational instrument implemented to facilitate development and it is ranges from

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transfer of mono-crop technology to participatory problem solving educational approaches, which aims at reducing poverty and enhancing community involvement in the processes of development."

Introduction

Sustainability Challenges

Nowadays, global concerns are growing about the destructive effects of modern agricultural technologies on the environment and natural resources and the long-term sustainability of agricultural systems (Tayleur et al. 2017). Soil contamination, soil erosion, water pollution, excessive use of chemicals, water wastage, the depletion of ground tables, the degradation of natural habitats of wildlife, and the increasing resistance of pests to pesticides are only a few sources of concern for environmentalists, ecologists, agronomists, policy-makers, and the public (Coll and Wajnberg 2017). Despite these environmental impacts, modern agriculture has been involved in many socioeconomic developments in both industrialized countries and the third-world countries (Srivastava et al. 2016). For example, one can mention the loss of employment, the shift of economic opportunities from women to men, growing specialization of livelihood, governmentalization of rural institutions in some countries, the increased concentration of lands in the ownership of wealth villagers and urban investors, the growing gap between wealthy and poor villagers, the adherence of rural institutions to governmental goals, and many others. These concerns have led many researchers to take an in-depth look at the agricultural activities so that they can present solutions to recover agricultural activities by considering technical, social, and economic challenges. The alleviation and/or mitigation of the environmental crises along with socioeconomic problems requires considering the issue of sustainability and sustainable development of agriculture. In fact, sustainable agriculture has emerged as a management philosophy and a system to meet agricultural needs of the present and future generations in response to the natural and human-made disasters and problems as the main challenge of the twenty-first century; according to this concept, agriculture should be less consumer and more producer (Leeuwis 2004; Rasul and Thapa 2003; Qamar 2002; Pretty 1995a; Allahyari 2012; Allahyari 2009a).

In short, modern agriculture is unsustainable and is unable to produce adequate food for the world population in the long run because the conditions that make farming possible are disrupted. Modern human has threatened the necessary factors of life including water, soil, plants, and air to ensure his livelihood and has created adverse conditions to satisfy his own needs. Thus, if today's societies do not change their direction, they will encounter many crises; that is, we will not have safe water, safe and adequate food, and healthy environment in near future (OKP 2013).

Three issues are important for sustainable agriculture: eradication of poverty, food security, and the health of the environment. Nonetheless, these issues are interrelated so that, say, the conservation of the environmental quality and the economic development are interrelated and mutually reinforce one another in the long run. More precisely, the school of sustainable development basically deposits that there is a mutual relationship between poverty and environmental degradation (Hope 2007; Gray and Moseley 2005).

In the other hand, the global demand for food is increasing quickly, resulting in agricultural expansion and a growth in associated environmental degradation. It has been projected that by 2050, the demand for crops will be 100–110% higher than 2005 levels. As the global population edges toward 9 billion, the required increase in food production must become more sustainable, socially, environmentally, and economically. The provision of knowledge, research, and innovative technologies through extension systems will play a vital role in this sustainable development (Brennan et al. 2016).

Agricultural Extension Toward Sustainable Food Chain

As a rule of the thumb for development in general and for agricultural development in particular,

human and his knowledge is critical with an undeniable impact (Sharghi 2005; Asadi and Shams 2003). Likewise, world development report 1998–1999 acknowledges information/knowledge as capital and the key for sustainable development (Sharifzadeh et al. 2003). Improvement in agricultural systems requires good information and sound advice. This has often been provided to farmers through public extension systems (Kidd et al. 2000). Leeuwis (2000) states that access to adequate knowledge is the prerequisite to accomplishing sustainable development. However, he asserts that this knowledge has a different nature than its present forms. He argues that more sustainable agricultural systems require access to adequate knowledge and technology, their exchange, and their application. Sustainable development needs various factors to realize its goals. Four essential factors are technology, institutional and organizational development, human resource, and agricultural research and extension. Among these factors, investment in human resource (extension) to improve their awareness and train them is of crucial importance (Farajollah Hosseini and Shariati 2003). Overall, more sustainable food production systems are more knowledge-intensive than to be input-intensive. Compared to new and conventional industrial agriculture, more sustainable agriculture has some more complicated aspect and calls for the practice of management with more economic and ecological diversity (Roling 1994; Garforth and Lawrence 1997; Cho and Boland 2004; Allahyari 2011).

Pretty (1995a, b) argues that in sustainable agriculture, farmers do not gain more yield from less inputs. They have to replace knowledge, management skills, and labor to compensate for the previous value added of the external inputs. When we talk about management knowledge, this reflects the presence of extension in sustainable agriculture. Francis et al. (1990) confirm this and add that information is so precious that it can be substituted for inputs in the agronomic systems. The ability to use information can be an essential component of sustainable agriculture. This is an emphasis on the significant role of education and extension in sustainable agriculture. Numerous studies have demonstrated that extension is a source of knowledge flow that is among the most important factors underpinning agriculture sustainability (Zecca and Rastorgueva 2017; Hasan and Khalil 2017; Sharghi 2005; Farajollah Hosseini and Shariati 2003; Salmanzadeh 2002). Presently, agriculture constitutes a major part of extension programs (Al-Subaiee et al. 2005; Minarovic and Mueller 2000).

Extension is an educational and guidance institution with a critical mission to inform the community about the implications of some agricultural activities on the environment and natural resources. So, the efforts of extension service should focus on developing the thoughts, behaviors, and actions of rural people by enhancing their social knowledge and technical skills in order to evolve them with respect to sustainability in the food chain (Farajollah Hosseini and Shariati 2003). The diffusion and use of improved agricultural technology and management practices can be dated back to thousands of years in different parts of the world, including China, Mesopotamia, Egypt, and even in the Americas. In the middle of the nineteenth century, during the potato famine in Ireland (1845–1851), agricultural advisors helped Irish potato farmers diversify into different food crops; it implies that historically agricultural extension started his mission to meet food security, and from the first, these were along together.

The term extension itself was first used to describe adult education programs organized by Oxford and Cambridge universities in England starting in 1867; these educational programs helped extend the work of universities beyond the campus and into the neighboring communities. This term was later formally adopted in the United States in conjunction with the land grant universities that were originally established as teaching institutions during the 1860s. Research activities were added in 1887, and extension activities were started in the 1890s and then formally added in 1914 as part of each university's official mandate (Swanson and Rajalahti 2010). The US Agency for International Development (USAID) played an active role in establishing agricultural universities and extension systems

during the 1960s and 1970s; as a result, many national systems still carry the "extension" title. On the other hand, nearly all extension systems are officially connected with ministries of agriculture; therefore, an increasing number of countries, especially in sub-Saharan Africa, now use the term "advisory service" (Swanson 2008). Agricultural extension systems follow major agricultural development goals: (a) achieving national and household food security, (b) improving rural livelihoods and achieving household food security, and (c) strengthening natural resource management (Swanson and Rajalahti 2010; Swanson 2008).

After one century experience, we are facing with many shifting toward new considerations in extension goals. For example, likewise, Hersman (2004) argue that research and extension should consider environmental considerations, social issues, and economic growth in the agricultural sector (Reddy 2015). To them, the use of educational materials is influential on the efficiency of sustainable agriculture as an agronomic method. Bull et al. (2004) suggest that the context and need have been increased more than ever for extension training to produce healthy, safe, and high-yielding food. According to the International Food and Policy Research Institute (IFPRI), global food production must be increased up to 80% by 2050 to meet the growing demand, and extension systems should play a significant role in this regard (Ajayi et al. 2018). Furthermore, extension activities can act as a systematic approach and prepare animal farmers to meet their commercial and environmental goals. Extension service has helped many crop and animal farmers adopt the frameworks of management systems such as the breeding programs of dairy herds, irrigation system management, nutrition management, and IPM (Harrison 2002). On the other hand, many researchers (e.g., Leeuwis 2004; Qamar 2002; Ahmadvand et al. 2005; Shahvali and Abedi Sarvestani 2005; Hayran et al. 2018) view agriculture sustainability as a factor that should be focused on by future extension programs. There is a close relationship between extension and sustainability, both of which are intertwined with social and farm life. Sustainability refers to the continuation of life, and extension teaches how life can be sustained (Özcatalbas et al. 2017).

When it is assumed that knowledge systems (extension) are a key component of the movement toward sustainability of agriculture, then fundamental questions are posed that can help us accomplish a sustainable agriculture extension system – questions like "What is the nature of knowledge required for extending more sustainable forms of food production systems?", "Are merely technical issues important, or should social-organizational aspects be considered?", "In the context of which social component are farmers able to establish more sustainable production units?", "What are the social bottlenecks with respect to these components?", and "How can motivational conditions be created?" (Leeuwis 2000). In general, sustainability cannot only be created on the biophysical and ecological ground because the status of "hard systems" strongly depends on the interactions between multiple human beings of "soft systems." This represents a holistic view of the process of sustainable food production as has been noted by researchers frequently (Minarovic and Mueller 2000).

Historically, the term agriculture extension has been evolved from the mere emphasis on production at the beginning of the century to productivity-based (or efficiency-based) agriculture to new philosophy of sustainability (Prokopy et al. 2015; Özcatalbas et al. 2017). Agricultural extension is the process of providing information and communication support to the users of renewable natural resources and encompasses offering advice, helping farmers analyze the problems and identify the opportunities, facilitating information, supporting group formation, and facilitating collective action (Mar Cho and Boland 2004; Garforth and Lawrence 1997; Lubell et al. 2014). Extension has been traditionally linked to production goals, but food security, better nutrition, justice, and poverty eradication have recently moved up in the agenda of extension service-providing organizations (Garforth and Lawrence 1997; Wheeler et al. 2017). From a historical perspective, three approaches can be distinguished for agricultural extension although they cannot be separated clearly in practice.

They include technology transfer, farmer first, and participatory learning and action research.

According to Vanclay and Lawrence (1994), "traditional extension has been a top down process: scientists developed products and methods which, following promulgation by extension agencies, farmers were expected to adopt. Extension agents considered farmers who failed to adopt new techniques to be recalcitrant and irrational. Farmers' attitudes and their lack of knowledge were considered to be the main barriers to adoption. Little consideration was given to farmers' points of view." One of the goals of extension is to transfer technology, and many people consider extension and technology transfer as one and same. However, extension is an essential and major part of technology transfer; the terms are not synonymous. Technology transfer was the first mission of this kind of traditional extension.

The transfer of technology approach is the dominant paradigm for technology development and adoption in agriculture (Lev and Acker 1994). Technology transfer is a linear and mainly technology-driven model that reflects the modernization developmental vision of the 1960s and is positivist in terms of the scientific paradigm. It encompasses three main actors: formal researchers, extension agents, and farmers or other clients accepting or rejecting innovation (Probst and Hagmann 2005). This model posits that the transfer of technology and knowledge from scientists and researchers to farmers will create reliable development. It is assumed in the model that the problems of farmers can be solved by people and organizations that are equipped with modern knowledge. The barriers to development were also regarded to include farmers who mismanage their resources instead of being innovators of solutions. The function of extension agents was to help farmers employ ready technologies irrespective of the fact that whether the technology was suitable. Technology transfer model creates an inflexible hierarchy that lacks information feedback. Researchers work independently of farmers and extension agents, and consequently, they have a poor understanding of farmers, opportunities, and hindrances. The technology transfer model has caused gaps both in the organization and in specialties. Research focuses on technology generation, and researchers and extension agents are viewed as technical agents. The model does not need a social element so that complicated social-organizational issues (e.g., land use regulations, power structures, and conflict settlement mechanism) are neglected or reduced to the technical level. The role of extension agents is to demonstrate modern technologies to pioneering farmers (Hagmann et al. 1999; Altalb et al. 2015).

The technology transfer model was extensively criticized in the 1970s: the extension of a linear model was the application of knowledge, and its task was to introduce practices and technologies to farmers without care for the fitness (suitability and its consequences). Its opponents believe that all agronomic problems can be solved by adhering to the mere conventional science. The dissemination/adoption model ignores major social issues such as the unequal distribution of technology impacts and benefits. Extension is offered to more literate and wealthier farmers. The diffusion/adoption model is employed for production innovations, not for the adoption of conserving technologies. The linear model of extension was only dependent on the extension of single technologies, whereas environmental management not only includes single technologies, but it also requires different thinking methods and whole systems. The model neglects farmers' local knowledge and assumes a trivial role for farmers to determine what they need and also for the development of technology. The cultural, political, and social environment of farmers and the adoption behavior are all overlooked, and adoption is regarded as only a personal decision. Finally, the dissemination model is not always based on predicted distribution, and adoption does not need to go through the phases of awareness, interest, assessment, and testing, especially with respect to the environmental innovations that are undividable and cannot be adopted separately. An early response to these inabilities was in-farm research efforts in that farmers put their farms at the disposal of researchers to do their research activities. This was considered as the cooperation

Agricultural Extension Systems Toward SDGs 2030: Zero Hunger, Table 1 Participatory methods and their focus

Method	Focus
Rapid Rural Appraisal (RRA)	Diagnosis and planning
Participatory Rural Appraisal (PRA)	Diagnosis and planning
Participatory Rural Appraisal and Planning (PRAP)	Diagnosis and planning
Participatory Assessment and Planning (PAP)	Diagnosis and planning
Participatory Learning and Action (PLA)	Diagnosis, planning and implementation
Participatory Impact Monitoring (PIM)	Monitoring and evaluation
Participatory Monitoring and Evaluation (PME)	
Participatory Farm Management Methods (PFM)	Planning in farm and household
Participatory Rural Communication Appraisal (PRCA)	Information and communication
Rapid Appraisal of Agricultural Knowledge Systems (RAAKS)	Information and knowledge systems
Participatory Technology Development (PTD)	Diagnosis, planning, implementation, and evaluation
Participatory Livelihood Analysis	Livelihood
Participatory Poverty Appraisal	Poverty

Source: Ponniah et al. 2008

of farmers. Then, the FSR/E research emerged in which an emphasis was placed on more participation of farmers to better understand the complicated conditions and interrelations of the elements of the agronomic systems in order to make the development of compatible technologies possible (Vanclay and Lawrence 1994; Allahyari 2011).

The technology transfer model was revised from the mid-1980s on, this time with an emphasis on farmers. At that time, participatory research methods were promoted to strengthen the types of research needed for understanding and strengthening farmers' own capacity to develop new knowledge to solve problems. The assumption was that farmers had considerable indigenous knowledge, and their ability to use and improve this knowledge could be strengthened through research (and extension) carried out in participation with extension workers (Rivera and Rasheed Sulaiman 2009). This has led to the development of various participatory approaches, tools, and methods. Experience has shown that participation improves the quality, effectiveness, and sustainability of development actions. Various participatory techniques have been used in the planning, implementation, and evaluation of projects.

As a result diverse range of approaches emerged such as Farmer First, farmer participatory research, Farmer First and Last, and the development of participatory technology. A number of broad approaches for participation and a large number of participatory methods have emerged in the recent past. Table 1 lists the key participatory methods that are being introduced. The most commonly used approaches are Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA), Participatory Learning and Action (PLA), and Participatory Assessment and Planning (PAP). The various tools used in these approaches are outlined in the next section.

Farmers became an integrated part of the process of innovation generation, testing, and appraisal, the innovations that promoted sustainable farming. The major expected results of these approaches were the generation and adoption of modern and suitable technologies by smallholders who had access to more limited resources in order to contribute to coping with the production obstacles to enhance farm productivity and income. The positivistic paradigm was still prevalent in this approach. Now, it is the turn of cooperative learning approaches to appear as the dominant model of extension. In participatory learning and action research, knowledge is

expanded through critical thinking and experimental learning (Hagmann et al. 1999; Probst and Hagmann 2005; Allahyari 2011).

Applying social/participatory learning is one of the most important features of extension-education methods toward sustainability. An important value of a social learning approach is that extension professionals are themselves enabled to learn their way through on how to work with farmers in a participatory, rather than didactic, top-down way while creating the social networks for facilitating exchange of knowledge between farmers as well as between researchers and farmers. In community-based approaches, by applying and developing farmer knowledge's, educating observation skills and using adult education methods to collaborative decision-making, extension would change toward facilitation (Allahyari et al. 2009).

But, what are the suitable goals for extension in its path toward the sustainability of future food chain? What goals should extension service set for it as a policy-making tool in order to drive the dynamics of the development of agriculture and food systems? Historical studies on extension goals show that since the initiation of extension in developing countries, the most fundamental objective of the extension organization has been increasing agricultural production. The primary goal of agricultural extension was transferring information from the global knowledge base and from local research to farmers enabling them to clarify their own goals and possibilities, educating them on how to make better decisions (Anderson and Feder 2004). Following World War II, a growing number of extension organizations were established in the developing countries, and "the transfer of knowledge and technology to increase crop production" was set as the goal of these extension systems (Allahyari 2008). After the emergence of the farming first approaches in the processes of agriculture extension and the failures of technology transfer model, extension goals were gradually shifted toward empowerment, participation, capacity creation (especially among farmer extension agents), and establishment or strengthening of local organizations (Lubell et al. 2014). The emerging participatory extension approaches, which are indeed the combination of the previous two approaches, pursue a much wider range of goals including improving the productivity of farming families via farming and other aspects of their life, motivating farmers' participation, mobilizing communities to participate in local development efforts, fostering the skills and potentials for local empowerment (especially for extension agents and farming leaders), and establishing (or strengthening) local organizations (Killough 2005).

Bull et al. (2004), citing Peters (2004), write that extension has been the prisoner of agricultural issues, but it should cover more extensive national goals. Presently, extension targets the life quality of the citizens. It will be crucial to have safe food and a high-yield food system whose supply will be among the goals of extension systems.

The goals of extension can range from the effective transfer of knowledge to the establishment of rural organizations that can influence future research and political programs. They can also take responsibility to make collaborative decisions on natural resource management and/or strengthen them (Cho and Boland 2004; Garforth and Lawerne 1997).

Some argue that the most important fields of development in future agriculture extension are learning more about agricultural production, the income of rural people, and environmental sustainability as well as more extensive use of comprehensive information resources like international information and local knowledge (Rivera 1997). So, extension services should give more serious attention to organizing information and communication. In a review of the literature on future extension and its trends, Ahmadvand et al. (2005) listed the goals of extension services as empowering, enhancing productivity, facilitating, and paying more attention to environmental sustainability.

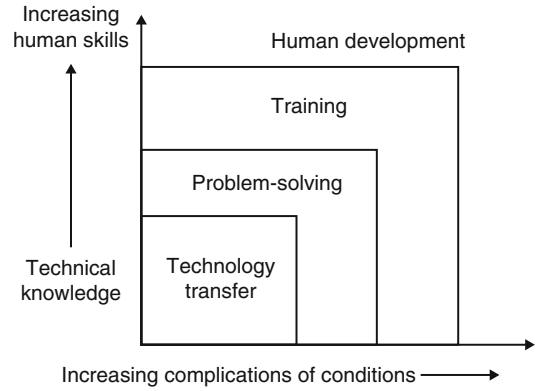
Conclusion

The second sustainable development goal of the United Nation is "end hunger, achieve food security and improved nutrition, and promote

sustainable agriculture." As well as with all other goals, the achievement of this goal specifically is impossible without giving true importance to agriculture sector (Özcatalbas et al. 2017). Agricultural extension works within a wider knowledge system that encompasses various components including research and agricultural education (Rivera et al. 2001). The extension services mainly involve the transfer of agricultural information to the farmers. These messages constitute information that is taken by the farmers who are attempting to implement them in their farming practices. Agricultural extension is one of the effective tools to enable us accomplish the Sustainable Development Goals 2030, that is, the reduction and eradication of extreme poverty and hunger in developing countries (Kipkurgat and Tuigong 2015).

It has been established that the existing extension systems do not suffice to accomplish sustainable agriculture, and the technology transfer model is unable to make it possible (Pretty 1995a, b; Killough 2005; Roling and Van de Fliter 1994). The extension and technology transfer systems have been extensively criticized. Many researchers argue that achievement to sustainability as a certain feature of a soft system requires changes that are interweaved to one another in five dimensions: ecological agricultural methods, learning of these methods, learning facilitation, supportive organizations and networks, and desirable political environment. In fact, these interwoven dimensions form the ecological agriculture knowledge system that is different from the conventional agriculture knowledge system (Roling and Jiggins 1998).

Today, a major challenge of the extension systems in most countries is to accomplish learning extension organizations aimed at empowering their diverse clients by creating and strengthening capital and human capitals (Allahyari 2009b). It has been made clear that it is infeasible to realize a sustainable food system merely by relying on traditional unilateral extension methods; rather, learning methods and facilitation of the learning of ecological agriculture practices and the inclusion of farmers' local knowledge can make it likely to effectuate multiple dimensions and policies of sustainability in agriculture.



Agricultural Extension Systems Toward SDGs 2030: Zero Hunger, Fig. 1 The role of extension services in changing environments

Agricultural extension programs should be re-examined and adjusted so that they are made to contribute to creating and maintaining food security as well as biodiversity conservation on lands beyond the fences of officially designated protected areas (Abdu-Raheem and Worth 2013).

An overwhelming need is felt for the extension to train farmers about the mutual relationships among agricultural production, food security, population, and environment. Extension agents should educate male and female farmers on such subjects as problem-solving, decision-making, accounting management, dynamic groups, leadership, citizen participation, innovation and self-help, nutrition, programming, supervision and appraisal, applicable information technology, the significance of children training especially girls, networking with other rural organizations and farmers associations, and so on. Obviously, this enormous task requires in-service training courses that are compatible with extension agents and some necessary reforms in formal agricultural extension training programs (Qamar 2002). It seems that we should shift the focus from making specific behavior changes to awareness enhancement. Extension roles are changed from offering advice by relying on technical expertise to facilitating learning processes for both farmers and extension agents (Allahyari et al. 2009). Figure 1 depicts the hypothesis that the type of extension will change when the conditions become more complicated and farmers need more fierce need

for knowledge and skills. Various works have revealed that sustainable agriculture is not confined to just a simple matter of behavior change or technology adoption. It appears that what is important is to enhance farmers' self-confidence to engage and play a role in the process of agricultural development. Relationship with farmers is not just an instrumental or strategic relationship, but this role needs new skills and attitudes among extension agents (Fig. 1; Somers 1998).

Technology, science, agriculture, state, and indeed everything are constantly changing. These changes in different economic, social, political, and technical fields undoubtedly affect extension institutions and develop them (Rivera 1997). As the problems and challenges faced by the agricultural sectors are changing over time, we should adapt our opinions about the role and concept of agricultural extension (Leeuwis 2004). If we consider the forecast of future changes in society, technology, and applicant requirements within Sustainable Development Vision 2030, we will be able to manage extension organizations effectively. Overall, changes in the work environment make organizations create necessary changes in themselves if they want to perform their functions effectively. Without these changes, organizations are destined to fail or work ineffectively. Changes in the work environment, which are called change forces, are very different in terms of nature and domain of action, i.e., they can be political, technical, economic, or social, or they can be condition-specific, regional, national, or global. The impacts of these change forces may be instantaneous, short term or long term, or they may be direct or indirect. In response, the organizations may make reforms internally or externally (Qamar 2002).

In short, according to Ponniah et al. (2008), the environment of agricultural extension has been changing with more focus on food and nutrition security, poverty alleviation, entry of new actors such as the private sector and NGOs in the delivery of extension services, changed R&D paradigms, and bottom-up approaches for end-user involvement in decision-making. However, while the public spending on extension has been shrinking, the role of government in extension services delivery is also being examined, sometimes separating the financing of extension programs from the delivery of extension services. Alongside a new approach has been emerging: considering extension as facilitation and producers (farmers) as clients, sponsors, and stakeholders rather than beneficiaries. The key trends reflect global socioeconomic change and driven by key concepts such as participation, client orientation, decentralization, as well as developments in modern information and communication technology.

Cross-References

- Agricultural Intensification
- Agricultural Research
- Research and Innovation
- Rural Development
- Smallholder Farming
- Small-Scale Food Producers
- Sustainable Agriculture
- Sustainable Food Consumption

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