

# An Analysis of Agricultural Linkage and Technology Innovation System: with Special Focus in Ethiopia

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**Abstract:** *In today's world, information and knowledge is a power engine for development. Having a strong linkage between research, education, extension, farmer and other concerned stakeholders has the power to improve the performance of the agricultural system. Agricultural linkage encloses generating and transferring agricultural technologies to enhance productivity, reduce loss, and improve the livelihoods of beneficiaries as well as the country's economy. These technologies can be in the form of production packages, information or knowledge. Technologies need to be properly packaged to meet the needs of the target clients and achieve the desired level of productivity. The attributes of information largely depends on the effective transfer and practical application of the information. However, effectiveness of information system is inhibited by different factors. For example, although Ethiopia's economy is dependent on the agricultural sector, the growth of the sector is constrained by different factors such as inefficient information-knowledge and technology dissemination. Therefore, the objective of this review study is to analyze the current status of linkage between agricultural actors and extent of agricultural technology innovation system. The result of the review study shows that different factors are constraining the system. A weak-link between stakeholders and innovation actors, less participation level of extension professionals in the system, weak technological innovation of the system are among the main bottlenecks. Based on the findings, it is concluded that strengthening the link between stakeholders, enhancing the innovation of the sector and involvement of professional in the system are the basis to improve the efficiency of the system.*

**Keywords:** Innovation, Dissemination, Stakeholders, Technology, Actors, Agricultural linkage

## 1. Introduction

Agricultural information is defined as the data for decision-making and a resource that must be acquired and used to make an informed decision (Kaske, 2007). Information-knowledge is a power engine for development, but the attributes of information largely depends on the effective application of the information and the overall package of the technology. Agricultural system performance can be improved by having strong linkage between research, education, extension, farmer and other stakeholders. The aims of agricultural linkage enclose generating and transferring agricultural technological packages to enhance productivity, reducing loss, and improving the livelihoods of the beneficiaries in particular and the countries' economy in general. The technologies can be in the form of information or knowledge. Moreover, the technologies need to be properly packaged to meet the needs of the targeted clients and achieve the desired productivity.

In the last decades, agricultural information has increased rapidly however the effective transfer of agricultural information/knowledge is still a big challenge. The main factors affecting the effective transfer of agricultural technological packages to the end-users are knowledge level of the information users, access to information of end users, and readiness of farmers for adoption (Carrascal *et al.*, 1995 and Soleiman and Saeid, 2013). Therefore, comprehensive

transfer of research information/knowledge is crucial to increase the impact the agricultural information/knowledge and technology have on the livelihood of the end users (Acock and Reynolds, 1990 as cited in Carrascal *et al.*, 1994).

Agricultural innovation system approach is already recognized as a best means to using it as a comprehensive framework for analyzing the status of the agricultural system in developing countries (Klerx *et al.*, 2009). Open information transfer system in combination with interactions among the stakeholders is necessary for improved agricultural information transfer system (Bouma, 2010).

Involvement of all innovation actors in the information/knowledge exchange, the use of farmers' indigenous knowledge and farming systems are crucial (Aflakpui, 2007) to enhance information transfer, technology adoption rate of farmers, and make genuine decision on agricultural investment. Strengthening the linkage between all the innovation actors is important to hasten the information/knowledge or technology transfer system and also to increase the effectiveness of the developed and disseminated agricultural technologies. Establishing efficient knowledge/information transfer system in agriculture would help to attain efficient operation of agricultural system (Carrascalet.*al.*, 1995).

Agriculture is the mainstay of the Ethiopian economy and it contributes in all aspect of the countries development (ICRA, 2010; Kasa, 2008; Kasa, 2003). For instance agricultural sector contributes about 60% of the country's gross domestic product (ICRA, 2010), creates employment opportunities for about 85% of the total population of the country and about 90% foreign exchange earnings contributed by this sector (Bishaw and Abdulkedir, 2003; Kasa, 2008; Kasa, 2003). The country is endowed with differences production environment which enable the country to produce a variety of crops and rear different species of livestock. Although the country is characterized by diverse agro ecological zone and endowed with ample natural resources which supports successful crop and animal production, the agricultural sector is less productive as compared to world average (Kasa, 2008; Kasa, 2003). Various factors contributed to the low productivity of the agricultural sector. Of all the barriers, the low level of agricultural technology development and innovative technological package transfer system by smallholder farmers are among the important factors (Kassa, 2003). Although agricultural extension has long history in Ethiopia, the coverage is very low and the linkage of the actors of the system is very poor, which is the main reason for low adoption of improved agricultural technology/production system and inputs (Kassa, 2003). Poor linkage of the stakeholders, coupled with disregarding farmers' indigenous knowledge in extension program and during policy development process, makes the linkage ill-functioning (Kassa, 2003). This calls for improvement of the linkage between the different stakeholders and innovation level of the sector so as to improve the livelihoods of smallholder farmers in particular and nations in general. Therefore, the main purpose of the current review study was to analyse the status of the existing link between agricultural actors and technological innovation extent of the sector so as to indicate the future intervention areas.

## 2. Discussion Part of the Paper

### Agricultural Knowledge and Information

Information theory conceptualizes 'information' in terms of a flow of 'messages' 'that have 'news value'; that is the cause surprise to recipients (Clark *et al.*, 2002). Similarly, agricultural information is defined as the data for decision-making and a resource that must be acquired and used to make an informed decision (Kaske, 2007). For the purpose of this paper, the phrase 'agricultural information' includes not only the information that comes from specialized agricultural sectors and one way flow to the farmer but also the agricultural information and knowledge obtained and flown from farmers themselves to the agricultural organizations or to other farmers as well as from and to other stakeholders in the agricultural sector. According to Spielman *et al.* (2002), information can be sourced from different actors; including public sectors (research, extension, universities, enterprises etc.), private sectors (traders, entrepreneurs, and companies), farmers' cooperatives, NGOs, individual farmers, families and rural communities.

Farmer is one of the most important sources of knowledge since farmer has the chance to observe his/her production environment and learn from his/her day-to-day production practices. But, farmers have no room to forward their knowledge/information towards improving the production possibilities (Clark, 2002). Further, the specialized sector and also other farmers do not give attention to the implicit knowledge of farmers. This is due to the existing practice of conventional information system which allows only one way flow of information. Clark (2002) described the one way or linear information flow as top-down transfer of technology in which the agricultural practices are diffused in one direction without any complex information exchange between different actors and without giving room for farmers' knowledge. This is because of the interest of the professionals or extension agents just to transfer what is considered best practice by themselves to the poorest farmers without taking into consideration the indigenous knowledge of the farmers. Spielman *et al.* (2010) described the linear information flow process in which the information/knowledge only transfers from the scientists to extension agents, and then, to farmers as having diverse actors and interactions within these different actors to address efficient knowledge/information transfer and increase agricultural innovation. For a technology to be accepted and adopted by the end user – farmer- it is important to consider the farmers local or indigenous knowledge since the developed technology will be applied by them. Unless the technologies are not accepted and used by the farmers, all the effort becomes useless. This is because; according to Glenna *et al.* (2010) the end users may totally resist to accept the technological change if they do not participate during development of the technology and the information about technology. Moreover, according to Douthwaite *et al.* (2000), good management needs the participation of all stakeholders in the early adoption stage of the technology as it creates the chance for key stakeholders to learn and make innovative improvement by themselves.

### Generation and Use of Agricultural knowledge and Information

Any kind of agricultural linkage, generates and transfers agricultural technologies so as to enhance productivity, reduces loss, and improves the livelihood of the beneficiaries as well as the country's economy. These technologies can be in the form of information or knowledge. The technologies need to be properly packaged to meet the needs of the targeted clients and achieve the desired productivity. To address this goal, different issues need to be taken into consideration such as publishing technology transfer, increasing publication/production guides, farmers handbooks, making publications available in the language understandable by farmers, ensuring the availability of publications to transfer agents, organizing field days and demonstrations, enhancing the relevance of training materials used for technology transfer (Aflakpui, 2007). Transferring the information/technology is not the end process (Douthwaite *et al.* 2000), but rather an effective way of developing technology demands adoption of the new technology by key stakeholders, and follow-up of the technology's continual development in collaboration with all

the concerned stakeholders. Furthermore, it needs to evaluate the impact the transferred technology brings about on the users' livelihood and different feedback mechanisms can be used to do so. According to Aflakpui (2007), evaluating whether the intended objectives will be achieved or not by the applied technology, implementation of survey, holding meetings, making field visits, and reporting the follow-up team is an important means.

### **Role of Agricultural Information in Development**

Information/knowledge is a power engine for development, but the attributes of information largely depend on the effective use and application of the information. The overall agricultural system performance can be improved by having strong linkage between research, education, extension, farmer and other stakeholders (Van Crowder and Anderson, 1997) since it improves the efficiency of technology transfer and adaptation. According to Abdulahi, (undated), unless information/knowledge is packaged with technology effectively, it is worthless to develop and disseminate technology. Agricultural information empowers farmers/farmer-based organizations to be conscious to select and adopt technologies in an informed way, operate along sound business lines, provide updated market prices of production inputs and outputs to farmers and play an advocacy role to influence agricultural policy (Aflakpui, 2007). On the other hand, information empowers the extension agent to network, collaborate and facilitate linkage between farmers and scientists/researchers and other stakeholders. In doing so, they become eager to upgrade themselves and to learn new things so as to easily communicate with all the involved parties and acquire knowledge to assess the service demand of farmers and look for solutions for the problems on the spot. Adoption rate of the transferred technology and the impact it brought on the users'/farmers' economy is the main measure of success of research and extension or technology. And the success depends on different but interrelated issues such as systems operating outside the research/extension (structural adjustment policy), training system, economy of the producer and price of the inputs vs. produce (Aflakpui, 2007). This shows the importance of the involvement of all the actors in developing adoptable technology, for better application of the developed technology and increase the productivity of the sector. This calls for the practices of the agricultural innovation system aimed at fostering inclusive networking among sets of heterogeneous actors (Klerx *et al.* 2009) rather than following the linear information transfer system.

### **Agricultural Information Transfer Mechanisms**

In the past decades, the traditional model of agricultural information and knowledge flow was practiced widely. In this linear/traditional knowledge and information flow system, the information and knowledge flows from research organizations to farmers through extension agents (Aflakpui, 2007 and Van Crowder and Anderson, 1997). Knowledge transfer considered as a hierarchical system which assigns researchers in the top, extension next and farmer knowledge at the bottom of the hierarchy (Douthwaite *et al.*, 2010 and Crowder and Anderson, 1997). According to Douthwaite *et*

al. (2010) this linear model/approach considers knowledge as flowing through a pipe-line. In other words, a research institute at the beginning of the system considered as a single source of information (Biggs, 1989 as cited in Douthwaite *et al.*, 2010), without further innovation practice. This system, in fact, underestimates the role of farmer, whereas extension considered as channel/messenger and researcher the producer of the technology (Van Crowder and Anderson, 1997). Even, when feedback regarding the transferred technology arises from farmers' side, it reaches back to the research through extension agents, which means that the farmers and the researchers do not come together and discuss on common concerns before, during and after the development of the technology. According to World Bank report (2006), in the linear model of innovation, public research organization considered as a key mover especially in developing countries' agriculture. Furthermore, this system is static in that it is not flexible to involve other newly developed actors. The modern system gives a room for farmers in the information and knowledge transfer system through active participation of the farmers, considering farmers' perception problems, indigenous knowledge and farming practices of farmers. Participation of farmers in research and technology development/transfer plays an indispensable role to overcome the failure of developed technology; this is the reason why variety on farm trials is becoming a popular part of research activity these days. Moreover, considering all the stakeholders in the information/knowledge system creates an opportunity to involve inputs from research, farmer, extension and other stakeholders in identifying and solving problems, and to set priority domains and reach consensus on different issues like taking own responsibility in technology development and transfer system (Aflakpui, 2007). Van Crowder and Anderson (1997), in their study on linking research, extension and education indicated the essentiality of farmers' involvement in technology development. Since it creates the chance to develop technological solutions to the problems that are acceptable by farmers. An integrated research system focus on linking farmers to specialized organizations to make the farmer an active participant in agricultural technology innovation activities and this approach gives attention for interactive, mutual knowledge/technology system (van Crowder and Anderson, 1997), which is opposite from that of traditional approach which emphasizes flows of information from research to farmers through extension. Moreover, the integrated approach gives a room for feedback from farmers and upward communication from farmer to the specialized agricultural sectors in order to increase the interaction between the different stakeholders in the sector. Furthermore, to change the conventional information/knowledge system to the modern/all-inclusive approach it is plausible to consider a wide array of institutions so as to increase effectiveness of information transfer system. This is because agricultural innovation as a process needs to involve a wide range of organizational types, whereas the conventional policy focus on public sector research organizations only (Hall *et al.* 2001).

### **Agricultural Research in Ethiopia**

Agriculture is the main-stay of Ethiopian economy and agricultural research has a long history in the country. Of late, the country is implementing agriculture-led industrialization/development policy. More importantly, raising agricultural productivity and improving rural welfare remains a fundamental challenge in the country (Spielman *et al.*, 2002). According to Spielman *et al.* (2002), the growth and innovation of the sector are still weak. For instance, between 1996 and 2005, agricultural GDP per capita grew only by 0.48 per year. Moreover, the growth shows fluctuation year to year (Spielman *et al.*, 2002). According to Spielman *et al.* (2002) this day's Ethiopian agriculture is changing as new actors, relationship, and policies influence the way smallholder farmers' access and use agricultural information and knowledge in their production activities. But still the impact these changes have made on the lives of the smallholder farmers and the change it made on their innovative activities are not quantified. This calls for further analysis of the impact of the aforementioned changes in the agricultural sector brought about on the life of farmers and innovating ability of the farmer as well as their involvement level in technology development and dissemination.

### **3. The State of Agricultural Information Transfer System in Ethiopia**

Agriculture and extension have a long history in Ethiopia, but the extension or information system was not efficient to reach all the relevant agricultural information to farmers/users. Moreover, the agricultural information/technology transfer approach designed without the participation of the end users, particularly for whom the technology is planned to reach (Kassa, 2008). According to Kassa (2008) the system also makes the farmers near the main roads beneficiary and ignores those located far away from the easily accessible areas. Similarly, the number of intermediaries is small compared to the number of farmers in the country. Consequently, it reduces the efficiency of information/technology flow. Currently, Ethiopian agriculture is changing in the way farmers get access to information and knowledge and use it in their production decisions (Spielman *et al.*, 2002) through assigning development agent workers in each locality who provide theoretical and practical assistance to farmers. According to Spielman *et al.* (2002), the change in the agriculture system of the country are assumed to create better opportunities for farmers, but the applicability and ultimate impact of this change on the farmers livelihoods is less visible. This warrants the analysis of the current states of information system and the role of different actors in the agricultural sector towards the improvement of the information and knowledge system as well as the change in productivity of the sector in the country. Adoption rate of agricultural technological package by the farmer mainly depends on the information and knowledge available for farmer about the technology. This is because farmers need being informed about the importance, method of application, application rate of the developed and disseminated technology. A study by Spielman *et al.* (2010) described the imperfect knowledge about new technology as one of the main barriers for less adoption and practice of agricultural technologies and

indicated information and experience as an important tool to reduce this constraints and hasten the dissemination, acceptability, adoption of technologies and thereby contribute to the improvement of the productivity of the agricultural sector and improve the economic situation of the farmer in particular and the country economy in general (Spielman *et al.* 2002). Information for agricultural sector comes from different sources. According to Spielman *et al.* (2002) for Ethiopian smallholder farmers, agricultural research institutes, agricultural extension agents, and higher education institutes are the most dominant sources of information, technology and inputs. According to (Rycroft and Kash 1999 as cited in Spielman *et al.* 2002) an array of social networks is an important element of an innovation system since different innovation actors interact with one another, or the set of individuals or organizations in which each has connections of some kind to some or all of the members of the set. This calls for the involvement of all innovation actors in the agricultural sector of the country so as to improve the development and adoption level of the technology and thereby improve the livelihood of the smallholder farmers in particular and the country's economy in general. This is because the economy of the country is agriculture dependent (ICRA 2010; Spielman *et al.* 2010; Kassa, 2008). Moreover, the change in productivity of the agricultural sector is not only impacts the smallholder farmers rather it contribute a lot to the improvement of the country's economy as a whole.

### **4. Barriers to Research and Dissemination of Technology and Information**

Executing research needs a lot of expenses and if followed by proper dissemination of the developed technology the investment becomes meaningful. The effective development of technology and dissemination of the knowledge/information obtained from the research challenged by different factors. According to Day *et al.* (1994) lack of efficient communication is among the major barriers in the execution of research, dissemination of results to the desired user and effective application of the technology as proved by research. Moreover, the absence of efficient communication about the technologies might result in poor decision making, delay in the planned activities, and failure and deficiencies in the dissemination of research results thereby the technologies remain without use for the desired objectives/impacting the end user (Day *et al.*, 1994). This shows the importance of having strong linkage between the different information/knowledge system partners. This is because having good linkage between stakeholders ensures the transfer of information and knowledge among the different stakeholders properly and helps to achieve the desired objective. According to Aflakpui, (2007) the function of linkage is more than just transfer of information/knowledge; rather it helps to perform diagnosis, planning and review of programs, execution of collaborative works, evaluation and feedback in a cooperated manner. The same study also suggests different mechanisms on how to sustain linkage between farmer and other actors such as survey, meetings, reports, training, demonstrations and field day. This also helps the farmer to select the technology in an informed way thereby enhance adoption rate of the technology. Moreover, weak link between research,

education, and extension and also the contact these organizations have with farmers is among the main bottlenecks in agricultural technology development, transfer and adoption level and thereby reduce the contribution of the technologies to development (Van Crowder and Anderson, 1997). Government policy and organizational structure also affect the linkage between the different parties in the agricultural sector. This is because the different groups/members in the linkage/information transfer system act in accordance to the policy. And if, for instance, the policies centralized, it might inhibit the flexibility that allows the different stakeholders to be responsive to each other as well as to farmers. Furthermore, absence or miss structured linkage may result in repetition of the same task by the different parties of the system, or result in failure to perform certain tasks (Van Crowder and Anderson, 1997). However, in recent years, a pluralistic approach of communication or linkage structure has been used. And this seems better in terms of flexibility, complementarities, and also in terms of range and number of farmers involved in the system and their technological needs (Van Crowder and Anderson, 1997). Van Crowder and Anderson (1997) in their study on linking research and education, indicated the importance of an integrated approach, since this approach links all system members/participants. Moreover, this approach allows having agricultural knowledge and information system that draws on both modern science and indigenous knowledge of the farmers. According to Van Crowder and Anderson (1997), interaction among different actors helps to produce better knowledge different from those produced by one actor alone. This shows the need to look at agricultural knowledge and information at a system-wide base to include all partners (education institutes, research, extension, NGOs and farmers indigenous knowledge) and to benefit from their expertise (Zijp, 1993 as cited in Van Crowder and Anderson, 1997). Following a systematic knowledge chain in the way that it allows interaction with the policy maker is also desirable (Bouma, 2010) since the policy makers are among the important parties that play a role in shaping and strengthening the information and knowledge system. Moreover, Hall *et al.* (2001) suggested the need for collaborative relationship between public and private, and research and non-research organizations to assure successful technology development.

## 5. Conclusions

This review study revealed that the factors constraining the linkage between stakeholders and technological innovation level of agricultural sector are wide ranging from poor linkage between stakeholders, innovation extent of the system, weak involvement of professionals in the system and dependence on traditional technology communication system. Based on the findings of this review study, it can be concluded that as the improvement of the system and the overall impact the developed technology bring about change on the lives of the poor is concerned the linkage between concerned stakeholders and technological innovation level of the sector should be improved.

## References

- [1] Abdulahi, M. (Undated/after 2006) 'Access to information: The dilemma for rural community development in Africa,' Department of Library and Information Science, *Bayero University Kano, Nigeria*.
- [2] Aflakpui, G. (2007) 'Present outlook and transformation in the delivery of agricultural extension services: Implication for research-extension-farmer linkage' *Outlook on Agriculture*, 36 (1): 35-39.
- [3] Bouma, J. (2010) 'Implication of the soil paradox for soil science,' Burlington: *Academic Press*, 106 : 143-171.
- [4] Carrascal, M.J., Pau, L.F. and Reiner, L. (1995) 'Knowledge and information transfer in agriculture using hypermedia: a system review,' *Computer and Electronics in Agriculture*, 12: 83-119.
- [5] Clark, Norman (2002) 'Innovation systems, institutional change and the new knowledge market: implications for third world agricultural development. *Economics of Innovation and New Technology*, 11(4-5): 353-368
- [6] Day, D., Dosa, M., and Jorgensen, C. (1994) 'The transfer of research information within and by multicultural teams,' *Information processing and Management*, 31(1):89-100.
- [7] Douthwaite, B., Keatinge, J.D.H. And Park, J.R. (2000) 'Why promising technologies fail: the neglected role of user innovation during adoption,' *Research Policy*, 30:819-836.
- [8] Glenna, L. Jussaume, R. and Dawson, J. (2010) 'How farmers matter in shapping agricultural technologies: social and structural characteristics of wheat growers and wheat varieties,' *Agric Hum Values*, DOI 10.1007/s10460-010-9275-9
- [9] Hall, A., Bocket, G., Tylor, S., Sivamohan, M.V.K. And Clark, N. (2001) *World Development*, 29 (5): 783-797.
- [10] Kaske, D. (2007) 'Agricultural information networks of farm women and role of agricultural extension: the case of dale Woreda, Southern Nations Nationalities Peoples' Regional state, MSc thesis, Haramaya University.
- [11] Kassa, B. (2008) 'Linkage of higher education with agricultural research, extension and development in Ethiopia,' *Higher Education Policy*, 21:275-299.
- [12] Kassa, B. (2003) 'Agricultural extension in Ethiopia: the case of participatory demonstration and training extension system,' *Journal of Social Development in Africa*, 18 (1):19-84
- [13] Klerkx, L., Hall, A. and Leeuwis, C. (2009) 'Strengthening agricultural innovation capacity: are innovation brokers the answer?,' *International Journal Agricultural Resources, Governance and Ecology*, 8 (5/6): 409- 438.
- [14] ICRA (2010) 'Multi-stakeholder linkages in rural innovation process in Amhara region, Ethiopia,' *Working Document Series* 137.
- [15] Soleiman, R. and Saeid F. (2013) 'Affective Factors in the Wheat Farmers' Adoption of Farming Methods of Soil Management in West Azerbaijan Province, Iran' *International Journal of Agricultural Management & Development*, 3(2): 73-82.
- [16] Spielman, D., Davis, K., Negash, M and Ayele. G (2010) 'Rural innovation systems and networking:

findings from a study of Ethiopian smallholders,' *Agri Hum Values*, DOI 10.1007/s10460-010-9273-y.

- [17] Van Crowder, L. and Anderson, J. (1997) 'Linking research and education: why is the problem so persistent and pervasive?,' *The Journal of Agricultural Education and Extension*, 3 (4): 241-249.
- [18] WANA NARS Study (1999) 'The national agricultural research system of Ethiopia'.
- [19] World Bank report (2006) 'Enhancing agricultural innovation: How to go beyond the strengthening of research systems.'