Approaches to adoption of innovation as an adaptive measure to climate change

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Abstract: *A key mitigation measure to climate change is adoption of new innovative technologies and practices by small-scale farmers. To support this, the barriers to adoption need to be identified. Combining qualitative farm-life-span interview with cost-benefit analysis, tackling questions arising from the qualitative research, gives both a local and a general perspective. Together the approaches give a holistic picture of the individual farmer's challenges, as part of a farming system. Intervention activities need to be developed in collaboration with local stakeholders; the experts on local society and issues such as religion, gender roles and family structure and possible windows of opportunity.*

Keywords*: Africa, agriculture, innovations, innovation system, adoption, adaptation,*

Introduction

This discussion paper outlines the methods for a qualitative socio-economic component of the research project *Characterization and conservation of Ethiopian Rhizobal Biodiversity, and Exploring their use in Sustainable Agroforestry* (ETRHICON). The main goal of the project, which started in 2006, is to investigate unexplored biodiversity resource and develop an innovative utilization of woody plants and their plant growth promoting bacteria i.e. nitrogen fixating root nodule bacteria, Rhizobia, as organic fertilizer in sustainable agro-forestry practice. The socio-economic component will look at aspects of the local community which support or counteract the adoption of these innovative methods. The research will look at which aspects of adoption of innovation theory can be useful for building a methodology and theoretical framework for the fieldwork phase.

Background

One of the great challenges of the coming century, which should be viewed as a global concern, is the effect of climate change on low income country agriculture and the influence this will have on local societies as well as both local and global economies. Developing countries are the most vulnerable to climate change due to their dependence on agriculture in their economies, their lack of resources for adaptation, their climate and exposure to extreme events (Fisher et al., 2005). This is the case in large parts of Sub-Saharan Africa and in particular Ethiopia, where close to 80% of the population get their income from agriculture, directly or indirectly (Deresa et al., 2008).

During the 20th century science has contributed enormously to increasing production. But modern agricultural methods have also caused extensive environmental damage (Foley et al., 2005) and many of the positive effects have yet to reach the poor small-scale farmers. The appropriate use of science and technology is also an important driver of agricultural growth (Asense-Okyere, Davis, 2009). Many studies have shown that one of the key mitigation measures to climate change includes the adoption of innovative soil conservation practices and other new technologies among local small scale farmers in Africa. "Technological breakthroughs, and their adoption on a large scale, have had high positive social payoffs" (von Braun, 2008). Correct land management can work both as mitigation and adaptation measures to climate change, at the same time having positive effect on several of the key Millennium Development Goals (MDGs). However, technologies that will work locally need to be identified and transferred in a sustainable way.

This raises questions about adoption and diffusion of innovations. The concern is that although innovative, sustainable farming methods and technology are investigated and recommendations given, they do not necessarily reach the end user, i.e. the local small-scale farmers. Or even if they reach the farmer, e.g. through some form of extension service, they may not be adopted by the farmers. This may be due to any one of a long list of possible barriers and many questions that may be relevant come into mind. E.g. if the major barriers are lack of financing possibilities or if the proposed systems for this are insufficient or badly functioning, not adapted to the local conditions? Or if the main problem is lack of support to farmers, e.g. through producer organisations, local disseminating strategies or other extension services? Or if it is the lack of technical knowledge in implementation or possibly of evidence of the benefits from the farmer's or farm household's point of view? The barriers may also be found on a deeper socio-cultural level, where issues such as family structure, gender, power relations, laws, regulations, traditions, customs, beliefs, norms and religion come into play.

Finding answers to these questions is not an easy task, but in order to develop relevant strategies to support the farmers in the adoption process, these issues have to be considered. These are all questions that research on and development of extension and other interventions should try to take into account. However, one problem is the strong assumption that providing evidence of the beneficial effects of certain actions will automatically lead to adoption. As will be discussed further into the paper, this is not an automatic process and a much deeper analysis needs to be conducted, in cooperation with local stakeholders. In fact, one of the most important questions, before even starting to look for the barriers, is whether the innovative method or technology is in fact relevant and needed in the community into which it is intended to be transferred?

The overall research question, which the socio-economic component focuses on, is how the use of rhizobia can be successfully introduced and adopted into small scale agro-forestry in Ethiopia. Specifically the research will focus on what the structures and features in society are that cause barriers to adoption. The aim of the research is to build a model for participatory communication for innovation to overcome these barriers and support the adoption of rhizobia.

In the following we will take some steps towards a theoretical framework on which the research approach is based. This will entail critically going through some of the theory on adoption and diffusion of innovation and relate these to agricultural extension activity. Then we will look at how other relevant disciplines may be linked to this research/theory and based on this make some assumptions on a useful approach for the fieldwork phase of this study. First we will, however, look at some relevant, climate-friendly land use strategies, particularly the use of nitrogen fixating bacteria, rhizobia, as organic fertilizer.

Climate-friendly strategies

As the case study of this research project concerns soil conservation strategies in Ethiopia, it is useful for the discussion to start by taking a look at some of the strategies and climate change mitigation methods that are currently used.

Researchers from International Food Policy Research Institute (IFPRI) Deresa et al. (2008) conducted a study of Ethiopian small-scale farmer's choice of adaptation strategies to climate change in the Nile basin of Ethiopia. The area is, much like all of Ethiopia, very vulnerable to droughts and is characterized by climate extremes. The researchers found that only 40% of farmers take any kind of measure at all. This is worrying, considering that the study was conducted in an area where 40% of the country's population lives and which is an area highly dependent on small-scale agriculture. Using a cross-sectional household survey as the base for their discrete choice model, the researchers look at a range of features, such as education, gender of household head, farm-size, financial state of household and, quite importantly, knowledge of environmental issues, to find out which are the ones to influence choice. Their main finding is that there is no single model or rule for choice. In some cases it seemed evident that female headed households were more likely to take adaptive measures,

whereas another case study came to the opposite conclusion, based on the assumptions that female headed households are likely to have higher financial and other market related barriers.

However, a common feature was that the main barriers included financial constraints and lack of information on adaptation strategies. Also, important features influencing choice were social capital as well as information and an understanding of environmental issues and the effects of climate change on the environment. Therefore, it is fair to assume that better information on adaptation strategies and alternatives would likely have an effect on farmers' choice.

The most useful and realistic mitigation and adaptation strategies will entail a multi-strategy approach, combining various different methods of sustainable land and soil fertility management. This has been suggested also by Sherr and Staphit in their discussion on farming and land use as mitigating measures to climate change in State of the World Report 2009. They take a holistic approach when stating that an "agricultural landscape should simultaneously provide food and fibre, meet the needs of nature and biodiversity, and support viable livelihoods for people who live there" (Sherr, Staphit, 2009). They recognise that all strategies to achieve climate-friendly landscapes need to make sense locally, i.e. be adapted to the needs of the particular farming community.

The climate-friendly agricultural practices they offer include enriching soil carbon, creating high-carbon cropping systems, promoting climate-friendly livestock production systems, protecting existing carbon stores in natural forests and grasslands, and restoring vegetation in degraded areas. The methods have the added value of working towards meeting aspects of the Millennium Development Goals (MDGs), through enhancing food production and reducing poverty among the small-scale farmers. The methods and technology are both cost-effective and relatively easy to use.

Rhizobia

One example of such a climate-friendly agricultural practice, which falls under both enriching soil carbon and restoring soil fertility, is the use of the nitrogen fixating root nodule bacteria, rhizobia, as organic fertilizer in sustainable agro-forestry practice. The effects and potentials of the use of Rhizobia have been described extensively by Lindström (2002) and will not be elaborated on here. But in short *nitrogen fixation* can be summarised as a biological process, where molecular nitrogen is reduced into ammonia (Franche et al., 2008). As most environments lack fixed nitrogen, it has led to the use of large quantities of nitrogenous chemical fertilizers. Plants are not able to assimilate molecular nitrogen themselves. This can only be done through a symbiosis between root nodule bacteria, such as rhizobia, and certain leguminous plants. Legumes, such as faba bean, soybean and groundnut, are considered the major nitrogen-fixing systems (Franche et al., 2008). Introducing these crops as part of an agro-forestry system can therefore have favourable effects also on other produce growing in the same environment.

The potential benefits of the use of rhizobia can be summarized in the following:

- substitutes the use of commercially purchased artificial fertilizers
- reduces expenses on output for the farmers
- has positive effects on the economic status of the farming household
- has positive environmental effects, such as
- sustains biodiversity
- improves soil fertility
- assists in soil conservation of degraded soils

Adoption and diffusion of innovation

As we can see from the summary above, many useful and relevant strategies exist that could support people in adapting to and mitigating climate change. This brings us over to questions concerning adoption and diffusion of innovation. Innovation is defined by Asense-Okyere and Davis as "putting ideas, knowledge, and technology to work in a manner that brings a significant improvement in

performance or product quality". (Asense-Okyere, Davis, 2009). There is a great deal of research, especially from a sociological starting point, that looks at the processes of adoption of innovations. Historically there have been many different top-down approaches, focusing on how to steer or direct change, something that Leeuwis refers to as instrumental models (Leeuwis, 2004). The models take a linear approach, where innovations are produced by scientists and intended to be transferred to the end-users.

The theories are largely based on the assumption that there are characteristics in society, referred to as structural properties by Giddens, which influence the capability for change (Giddens, 1984). These include a spectrum of aspects, such as traditions, structural features, previous practices and experiences. When these have been identified an adoption process can be designed accordingly. Fortunately this top-down approach has during the past decades largely been replaced by a more participatory approach, which takes into account the value of communication processes as part of adoption and diffusion. Also these models are, however, often based on a line of assumptions about individual behaviour. According to these, people - in this case farmers - behave based on what they believe to be true, aspire to achieve, believe they are able to and what they are allowed or expected to do (Leeuwis, 2004).

Leeuwis lists a set of problems also with this type of communicative approaches to innovation. Many of these are related to the scientist, researcher, extension workers or policy maker involved in the process. Among these there may be tendencies towards:

- disciplinary blindness
- reality reduction by policy institutions
- classification into target categories
- incomplete images, prejudices and biases of the researcher.

Without going further into these concepts, it can be summarised that the major criticism is related to how agricultural activity is in fact viewed. It is still not seen from a holistic view as a farming system, where all actors and levels of action are interconnected, further influenced by a large number of aspects, specific for a given community, such as tradition, religious, believes, economic systems, policy etc.

Although interaction and communication have been largely accepted as important aspect of the innovation process also by the scientific community, many assumptions still guide action. This can be observed in practice within many research and development projects in agriculture, based on the hypothesis that providing farmers with e.g. better information and market access or evidence of the long-term benefits of an investment, will create sufficient incentive for them to adopt new strategies and technologies. Subsequently extension programs are built up according to these assumptions.

Current problems of extension systems, apart from the fact that they have been grossly driven down in many parts of Africa, are captured in the Summary by Rasheed Sulaiman for IFPRI's conference on *Advancing Agriculture in Developing Countries through Knowledge and Innovation* in 2008. Even today extension has far too often been viewed as a linear process, going from the drawing boards of the academic researchers, through farmers' schools to the famers, to practice. Often times little to no effort has been put to actually establishing the existing networks and the underlying institutions and patterns that shape the interactions among the various actors involved (Sulaiman, 2008).

A further problem is the major gender inequality of current extension systems. At the moment only 5% of extension services are received by women (Asense-Okyere, Davis, 2009). At the same time these women produce up to 80% of food, especially in Africa and studies have shown that when provided with the same extension services as men, women farmers increase their productivity by 22% (Asense-Okyere, Davis, 2009).

Even when reforms in the system have been attempted, they have only targeted extension and its internal mechanisms, rather than viewing the larger structures they work in connection to. Many times also these would require reforms. However, this makes the issue quite political and requires both political will and good guidelines for policy makers. Both extension and other institutions in

society it interacts with need to go through a change process, developed specifically for and within the local context.

New approaches to innovation

In the past years applied research on adoption and diffusion of agricultural innovation have increasingly taken a more participatory approach and new theories and methodology concerning innovation processes have been created. Leeuwis' theories are based on the importance of communication as part of the innovation process (Leeuwis, 2004). Studies should be based on such questions as:

- how and why do process of innovation design and unfold?
- what characteristics of innovation processes contribute to sustainable innovations
- how do conflicts of interest between different stakeholders influence the process
- dynamics over time, influences of routines and feedback

The different actors involved in the communication process, and what roles they assume, is also an important aspect of Leeuwis' theories. Many of the conflicts involved in a communication process, may be eased by a facilitator. This person can in some cases be the scientist or extension workers, but may as well be some other stakeholder.

The most important is, however, to involve various local stakeholders with different interests, who have the actual knowledge of what the real problems are and also many potential solutions. Rural people have always used indigenous knowledge and experimented in new ways of using and adapting it. Therefore they are very well prepared to participate in and create new models for action (Asense-Okeyere, Davis, 2009).

Also Spielman et al. view the innovation process more as a dialogue and a non-linear system, where technological development and scientific understanding may not follow each other in the assumed order, but rather as a constant movement and reciprocal process. They define an agricultural innovation systems as "a complex process of actions and interactions among divers actors engaged in generating, exchanging, and using knowledge, and the social and economic institutions that condition their actions and interactions" (Spielman et al., 2008).

The authors apply this perspective on strengthening agricultural education and training (AET) in sub-Saharan Africa, viewing AET systems as innovation systems. "innovative capabilities among both individual and organisations [need to be strengthened], creating organisations cultures in AET that are sufficiently open and dynamic to facilitate change; and building innovation networks, partnerships, and linkages to foster greater adaption, imitation and use of available information and knowledge"(Spielman et al., 2008).

Innovation systems theory has been applied in practice e.g. through the establishment of Innovation Platforms within research projects. Innovation Platforms are "forums for participatory identification and implementation of strategies to develop competitive production systems and reduce transaction costs along the value chain" (van Rooyen, Homann, 2009). In practice this means that stakeholders from different spheres of the existing local value chain system, from production to consumption, meet to identify the particular constraints in e.g. production and marketing and suggest options for improvement through dialogue, implementation, evaluation and adaptation.

Combining qualitative and quantitative research approaches

Various sectors in society are involved in and influence farming systems in different ways. Policy, both local and national, is an important one. Policy has potential to promote sustainable solutions and to create incentives and functioning systems where these can thrive. Targeted recommendations for policy makers are therefore an essential part in promoting adoption of innovation.

In order to produce valuable recommendations a multidisciplinary approach needs to be adopted. The process has to start at a qualitative level, analysing the local society from an innovation systems approach. Here methodology such as observation, qualitative farm-life-span interview and innovation platform can be useful. Also aspects of the agricultural household model (AHM) as used by Karttunen, to understand household behaviour, can be applied to this. The perspective views a household as a production unit that makes choices concerning the allocation of total time and input based on assumptions of how utility and commodities will be maximised (Karttunen, 2009). This can be a good base for analysis, but the model needs to be adapted to take into consideration issues such as gender, relationships within the household as well as the household as part of a larger system.

AHM can function as a bridge over to a more quantitative approach and also be the basis for cost-benefit analysis. Qualitatively identifying the issues to study quantitatively, gives the research both a local and a more general and theoretic perspective. Quantitative models have no value in themselves if the variables are not relevant, based on the actual existing situation in a given society. On the other hand quantitative results can give useful insights into larger-scale structures and trends over time as well as effects of interventions and practices. Concrete performance indicators, to measure the effects of different strategies can be defined quantitatively. This is essential for presenting alternative scenarios to policy makers, decision makers, investors, donors and to show local decision makers what the effect different choices are likely to have in the long run. Although we have concluded previously that presenting evidence of benefits of certain activities (technologies, methods, investments) does not necessarily lead to changes in the modes of action, quantitative evidence is still a powerful too.

Way forward

We now come back to our research questions concerning the adoption of rhizobia as an organic fertilizer. At first glance it seems this is a typical example of a linear, science driven process, where a technology is produced and offered to the beneficiaries without asking whether this has anything to do with the actual problems (or solutions) they are facing. However, the claim here is that this could be part of a solution, which the local stakeholders themselves would be involved in developing. It should be possible to integrate this solution quite easily into current farming systems.

The important next step is to create a methodology, in collaboration with local stakeholders, for the qualitative phase of the research. An innovation platform could be established already at this point in time, to support the participatory planning process. The issues this platform needs to address concern current farming practices as well as perceived problems and potential for change. Questions to ask include who makes decisions on fertilizer purchase? How and when are these decisions made? What is the role of a potential farmers' organisation in such a decision making process? Has farmers training previously influenced such choice? What is the financial reality of using different options?

The risk here is that some essential stakeholders are left out of the process do to various biases, motives or interests of the local partners. The process should therefore be paired with observation of actual systems, networks and relationships within the community. An outside observer may not be able to detect many of the underlying meanings or features of the community, but on the other hand he or she does not have the bias of an inside perspective, which may also cause a local observer to disregard from certain (also harmful) practices.

Also the innovation platform method needs to be based on innovative communication patterns. Communication in itself can be problematic, due to various practices, values and norms, which influence the way in which people communicate and with whom. Actually making the process participatory requires more than just gathering a group of different stakeholders around a theme of common interest.

Leeuwis offers several different practical methods to use when managing communication processes. He is of the opinion that a lot of information on views and attitudes can be gathered already from

observing and analysing everyday talk and through in-depth interviews. In order to support communication in the group setting he proposes methods such as visual diagramming and mapping, ranking and scoring, problem tree analysis (Leeuwis, 2004). Such methodology could be developed even further using creative thinking theory, i.e. viewing issues from new and different perspectives. The main value of these types of exercises is that they open the door to creativity in a participatory manner and supports thinking along new tracks. This is a valuable and important part of the innovation process.

Conclusion

Science and research have the potential to assist policy makers in directing resources to the most relevant actions, affecting the agricultural sector in low income countries. This is also one of the objectives of this research project. If the benefits of the use of rhizobia can be presented in a quantifiable manner and guidelines on best policy practices and locally adapted extension systems produced, change can be promoted.

Some of the responsibility lies with the policy makers who need to develop and support institutions to create market incentives both for the farmers themselves and for other stakeholders within the supply chain. This may be done through promoting a mix of policies, e.g. interlinked contracts, which target land conservation at different levels and from different viewpoints.

The time may be right for a more active, as well as interactive, way of sharing best-practices also between policy makers, extension workers, researchers and end-users. The channels for communication today give such great opportunities for innovative ways for sharing and producing information. But even in a globalised world, characterized by information technology and communication, it is on the grass-root level that the actual decisions and choices concerning everyday life are and will be made. Therefore, in the end it is here that the innovation processes need to be brought.

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