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THE 'NATURE' OF DEVELOPMENT STUDIES
An Ecological Perspective on Uneven Development

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Farmer Participatory Research: An Approach to Fostering Community-led Innovation in Smallholder Agriculture

1. Introduction

In this article we suggest farmer participatory research as an approach to community-led innovation aimed at finding solutions to agronomic challenges in smallholder agriculture. We do this in recognition of the overriding theme of this special issue, i.e. uneven development across spatial and temporal scales. We acknowledge the wide range of applications of the term 'uneven development', as well as its political history. In our interpretation, uneven development describes economic disparities between continents, countries or societies. Applied to the smallholder agriculture of sub-Saharan Africa, 'uneven development' typically addresses global trade or international political economy concerns as well as unequal access to information, natural resources, financial services or social networks with political weight. Our contribution to this special issue draws attention to the agronomic challenges that smallholder farmers face in their daily struggle for more sustainable and secure livelihoods. These challenges are reflected in soil quality decline, increasingly variable weather conditions, pest and disease incidents, and, as a consequence of all these, increased crop production risks. An article about 'agronomic challenges' and smallholder response strategies is not trivial, exotic or outside the scope of this issue. Rather, such approaches offer relevant insights into local-level sustainability arising in large part due to the deficiencies in world political and economic structure. Undoubtedly, the problem of uneven development needs to be addressed at all scales. In this contribution, we offer one approach that can be taken at the local level, namely community-led innovation in smallholder agriculture to enhance the sustainability and well-being of local socio-ecological systems.

Finding solutions to agronomic challenges is important, because smallholder agriculture is confronted with a range of ecological obstacles that put food production at risk. This is of particular relevance in sub-Saharan Africa (Resnick 2004; Asenso-Okyere/Davis 2009). Although some progress has been made, it is still the region with the highest share of people living in poverty and food insecurity. Despite rapidly expanding urban and peri-urban areas, the majority of people living in poverty are rural and depend on agriculture (Ambrosini 2002; Waithaka et al. 2006). For that group, agriculture is a major livelihood strategy, yet one confronted with uncertainties and stress. At regional level, food crop productivity has more or less stagnated over the last 40 years. While crop productivity is not the only agricultural performance indicator, it matters to farmers whose lives depend on farming (Lobell et al. 2009). Beside food production, agriculture has essential social, cultural and environmental functions. Considering the paramount role of multi-functional agriculture for sustainable livelihoods, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD 2009) calls on governments to make radical changes in the way farming is supported.

The conventional development discourse emphasises science as the main source of innovation. While science is undoubtedly an important driver for innovation and change, agricultural research products often do not pass the stage of being good but isolated ideas. Following Schumpeter such ideas are, in the best case, nothing more than inventions. Such inventions remain irrelevant to farmers, if, as Assefa et al. (2006) suggest, they are not transformed into innovations by entering into the complex relations and interactions of people and institutions in wider socio-economic, cultural and political contexts. What many of these inventions have in common is the limited scale employed by the farmers that apply them. At the latest since Robert Chambers' plea for 'Farmers first' (Chambers 1989), smallholder agriculture is recognised as a complex, diverse and risk-prone undertaking. Supposedly benign technologies and agronomic practices generated by research do not always match with the needs and priorities of smallholder realities in sub-Sahara Africa. Moreover, it is now widely recognised that farmers themselves are important sources of new ideas. Farmer participatory research, as presented in this article, fosters community-led innovation and puts farmer research committees into the driving seat of technology development.

We wrote this article from an applied development research perspective. Applied development research is driven by practical development issues, such as degrading natural resources, declining access to land and water, or opportunities to tap local and international niche markets. Applied development research is empirical, draws on middle range theories and envisions the practical application of research insights. It is not a discipline per se, but describes a field of operations that draws on theoretical and methodological insights from natural, technical and social sciences. In our work, attempts to address uneven development, being the main theme of this article, begin with a simple question: how can farmers, within the given opportunities and constraints of the world-system, further develop multi-functional agriculture that contributes to household food security and sustainable livelihoods, while safeguarding ecosystem quality and contributing to societal well-being? Answers to this question shall help farmers and their representatives to identify more secure livelihood opportunities that otherwise remain neglected.

In the proceeding section we review some of the main arguments as to why technology transfer has so rarely been effective in sub-Sahara Africa. The subsequent section embeds farmer participatory research in the broader innovation systems debate. Based on this, we show how farmer participatory research works in practice. This article concludes with remarks about the value of applied development research for fostering innovation in smallholder agriculture in sub-Saharan Africa.

2. Why technology transfer failed

The transfer of technology model is a linear research and technology application process. It embodies a particular way of thinking about the role of science and its relationship with other sources of knowledge. In agriculture, this has been widely manifested in the idea of extension officers as specialized intermediary agents to transfer on-station research findings into farmer fields (Kerkhoff/Lebel 2006). Farmers are seen as either 'adopters' or 'rejectors' of technologies, but not as a source of technical knowledge, technologies and practices. As Kerkhoff and Lebel (2006) note, the traditional transfer of technology model assumes an objective truth that the scientists pass on to the farmers via extension officers, and farmers are assumed to make decisions independently on a technical basis (figure 1).

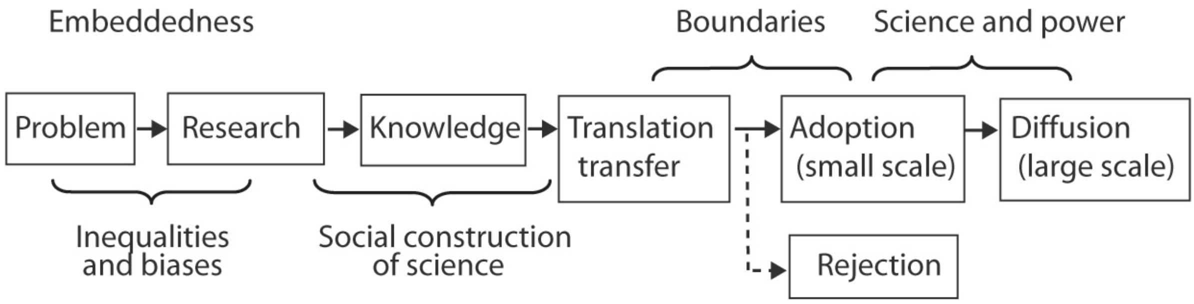

Figure 1: Critiques of the transfer and translate model
Source: adaption from Kerkhoff/Lebel (2006: 458)

Following attempts to introduce Green Revolution agriculture in sub-Saharan Africa from the 1960s onwards, transfer of technology thinking has dominated agricultural development (Critchley 2000). The basic assumption has been that technology packages of improved seeds, mineral fertilisers and synthetic pesticides handed over to farmers would increase agricultural productivity as rapidly as had been the case in south Asia. Agricultural technologies developed on research stations and further tested in researcher-managed on-farm demonstrations performed well, but were rarely replicated on farmer fields. It is now well documented that, in most parts of sub-Saharan Africa, the Green Revolution has failed (Kijima et al. 2011; Omanya et al. 2007).

But not only the type of agricultural technology is to be blamed, but also the way agricultural technologies have been developed and disseminated among farmers. Since the early 1960s, the 'diffusion of innovation' model was widely applied to frame and to plan for technology transfer from research stations via extension service providers to farmers (Rogers 2003). The model emphasises those social networks through which agricultural technologies spread over time. The mainstream 'diffusion of innovation' thinking perceives technology dissemination as a stepwise process, whereby new ideas, technologies and practices are adopted by different categories of people at different times. Rogers suggest that people should be classified into different adoption categories, rangeing from early to later to late majority and laggards (Rogers 2003; Rogers/Kincaid 1981).

For several decades, the extension service providers were blamed for the lack of adoption of agricultural technologies by farmers. But extension services also face several challenges, which include chronic under-funding since the 1980s, poor capacity to cater to diverse farming and livelihood strategies and to enable countervailing powers of smallholders to tackle unfair competition on world markets (Feder et al. 1999; Sharma 2002; Sulaiman/Hall 2002). What followed were poor records of extension services, in particular the World Bank-funded Training and Visit schemes. Technology package transfer from national research stations to farmers often failed because extension services could not respond to the many changes within the socio-economic, political and ecological environments within which it exists (Pretty 1995; Wallace 1997).

With time, criticism of the 'diffusion of innovation' model for neglecting the complexity of smallholder agriculture as well as the risk-prone context in which farmers operate grew. For example, the 'diffusion of innovation' model presents a rather one-way communication path, whereby researchers are the sources of agricultural information and technologies, technology dissemination was the responsibility of extension service providers, and the adoption of extended technologies is done by farmers. In reality, extension services providers and farmers themselves are co-developers of technologies (Probst et al. 2003; Wettasinha et al. 2008). Secondly, 'diffusion of innovation' thinking suggests that farmers decide between the adoption or the rejection of a technology or practice. While this is true for a certain set of technologies (e.g. new crop varieties), farmers rarely adopt the technology package as a whole. In reality, farmers carefully select technology components, sometimes farmers sequence the implementation of technologies (Leeuwis/Van den Ban 2004). Third, the 'diffusion of innovation' model was to a large extent developed under North American conditions, spearheaded by Land grant universities. Towards the end of the past century, partly influenced by several European donor agencies, the chapter of classical technology transfer thinking as briefly outlined in this section came to a close. This does not mean that transfer of technology is not practiced but only that it gradually disappeared from the official development agenda.

3. Innovation thinking in agriculture

Over a period of two decades, innovation concepts entered the agricultural research discourse. Yet these concepts refer to something intrinsically human. Innovation is, as Fagenberg et al. (2005) put it, ultimately linked to the human desire to think about new and better things and to try them out in practice. Innovation can be ecological, technical, economic, social or organizational. "Innovation is: production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome" (Crossan/Apaydin 2010: 1155). Innovation also communicates 'change' and 'transition'. For example, Sulaiman et al. (2006) or Hall et al. (2010: 14) understand innovations as "changes that takes place in societies, when knowledge, technology and information is made available and is put into socially and economically productive use."

Innovation is also a process of technological and institutional change at farm (and higher) levels that impact on productivity, income or sustainability (Röling 2009b). Leeuwis and Van den Ban (2004: 61) defined innovation as "a new pattern of coordination between people, technical devices and natural phenomena". This definition is rendered exhaustive by incorporating whole elements and components that innovation encompasses in actual practice. They consider innovation in a wide and to some extent co-evolutionary sense. According to them, changes 'never come alone', and often include technical, social and organizational elements. Or as Hellström (2007: 148) puts it: "eco-innovation must, in order to succeed, also build on relevant social structures and in some cases the innovation should also be able to influence these structures."

At a higher level, innovation takes place within a particular innovation system. An innovation system incorporates all actors that are needed to solve a particular problem. Innovation systems do not exist independently of a problem, but rather it is the problem that defines system boundaries. Because innovation systems are defined for a particular purpose, system boundaries may shift or the system as a whole may dissolve with time. In agriculture, innovation systems are frequently organised around production or market problems at national and local level (see innovation platforms of FARA; www.fara-africa.org). They ensure information flow in general or directed for a specific purpose (Metcalfe/Ramlogan 2005).

Innovation systems in turn are components of the larger innovation context, something labelled 'innovation ecology'. Innovation ecology is, as Metcalfe and Ramlogan (2005) point out, 'no system of itself until subsets of the actors are connected with the intention of promoting innovation'. Wulf (2007) defines innovation ecology as 'the environment comprising interconnected institutions, laws, and policies that create an innovation infrastructure that includes education, research, tax policy, and protection of intellectual capital'. Ecology as a metaphor helps to compare innovation dynamics to ecosystems. Each component of a given innovation ecology has a function and the ecology as a whole must be adaptable to environmental changes.

Several factors influence the innovation ecology of a given region or territory in which people are engaged in agriculture. These factors may include agricultural support services and micro-finance institutions, the nature of governmental policies, the availability of financial services or the operational of agricultural advisory programmes. The nature of the innovation ecology certainly influences the type of innovation that innovation systems can bring forth.

Interactions within innovation systems are typically non-linear with a range of decentralised decisions taken. All living organism, human and social systems are complex dynamical systems. All such systems have similar generic properties, including communication, iteration, cooperation, conflict generation or resolution, and organisation. In that sense, innovation is the emerging property of a 'soft system': new products, technologies or practices are no longer the result of a linear chain of events, but they emerge from the interaction among system actors. It considers innovation as the emerging property of social interaction and their interactions with the environment.

Boundaries of innovation systems cannot be determined objectively, but they are socially constructed. This implies that the definition of system boundaries created by researchers is likely to differ from those of extension service providers and from those of farmers. Everything that lies outside the system boundaries belongs to the system context, which is outside the sphere of influence from the perspective of the viewer or actor. In other words, technologies developed at the research station are – from a farmer's point of view – developed beyond their innovation system boundaries. If this is true, then the same applies to researchers, i.e. technologies developed by farmers are – from a researchers' point of view – developed beyond their innovation system boundaries.

With the help of organising forces, complex dynamical systems aim for the maintenance of their internal structure. The structure of a given system communicates with its environment and receives 'inputs' (e.g. in the form of external irritation), but in most cases they are not considered relevant. Externally developed solutions are beyond people's system boundaries. From a systems theoretical perspective, the imposition of behaviour onto smallholder agriculture is bound to fail and at best will result in compliance for material incentive. Supporting farmers to strengthen agriculture, notably to increase ecological sustainability, cannot be achieved through instructive interaction and expert advice. It is assumed that most of the solutions that farmers are able to implement in response to agricultural challenges lie within farmers' system boundaries. This also changes the innovation ecology, hence the conditions under which change and transformation takes place.

The term 'attractor' is a useful metaphor to describe what happens when a system resists outside intervention. Attractors can be seen as "a state or a reliable pattern of changes (e.g. periodic oscillations toward which a dynamical system evolves over time and to which the system returns after it has changed" (Coleman et al. 2007: 5). An attractor is an 'attractive patterns of human behaviour', an organised dynamic structure. These have two characteristics: an organised dynamic structure and resistance to disturbance. Following outside irritation, the attractor guides the system back to a new attractor.

4. Farmer participatory research in practice

In this section we turn to Hoima district, mid-western Uganda, where we observed farmer participatory research in practice. Hoima, which borders Lake Albert to the west, covers an area of 5,775 square kilometres and has a population of 341,700 people (Buyinza et al. 2008). The average annual rainfall is around 1,435 mm, with two peaks in April and October/November. The annual average temperature is 22.6°C (Uganda Department of Meteorology 2007 cited in Fötsch 2008). Small variations in temperature and humidity characterise Hoima's climate (Buyinza et al. 2008). The vegetation within the district is predominantly savannah grasslands ranging from medium altitude moist forests through forest/savannah mosaic and swamp to post cultivation communities (Oluka-Akileng et al. 2000 cited in Buyinza et al. 2008). Soils are mainly yellowish-red clay loams on sedimentary beds (Siriri/Bekunda 2001 cited in Buyinza et al. 2008). 95% of Hoima's inhabitants are involved in farming activities (Fötsch 2008) and the rain-fed and manually cultivated agricultural production mainly comprises of food crops as maize, cassava, millet, beans and sweet potatoes as well as cash crops such as tobacco, cotton, sugarcane (Buyinza et al. 2008; Fötsch 2008).

Hoima is served by the National Agricultural Research Organisation (NARO) Zonal Agricultural Research and Development Institute, which is specialised on seed multiplication, notably cassava mosaic virus-free planting material. Access to agricultural information and technologies was sporadic, extension on sustainable crop production offered by several national and international Non-Governmental Organisations (NGOs). Overall, the level of knowledge about effective sustainable agricultural practices is low. Soil fertility decline has been a concern of both farmers and external service providers. This concern increased in the wake of the privatisation of public extension services and a shift in focus to agricultural commercialisation. Despite access to information about sustainable agricultural practices being low, farmers had comprehensive knowledge about soil types and qualities. Names and descriptions for different soils and experiences with managing the more difficult soil types in the dryer parts of the region or on slopes helped them to take crop management decisions. Such local knowledge pools served as entry points for farmer participatory research.

In 2004, as part of a larger research project, one NGO and an international agricultural research centre together with two farmer groups and the Zonal Agricultural Research and Development Institute joined forces and engaged in a three-year experimentation in a quest to strengthen sustainable agricultural practices. Respective activities were embedded in the 'Enabling Rural Innovation' framework, aimed at developing profitable agro-enterprises while safeguarding natural resources (for details, see Kaaria et al. 2008). The implementation of the ERI process was mentored by the NGO, soil scientists, agronomists, resource economists and social scientists hosted by the international agricultural research centre were responsible for accompanying scientific research. As far as possible, the research team integrated insights and observations within their contribution to build theories around field level action.

Each of the farmer groups nominated a research committee, which was offered farmer participatory research training by members of the NGO and research team. These trainings started off with visits to the National Agricultural Research Organisation (NARO) Zonal Agricultural Research and Development Institute, which exposed farmers to agronomic experiments. In addition to such exposure visits, farmers received training in research priority setting (e.g. the formulation of research questions for improving productivity and soil fertility management), experimental designs and the monitoring and evaluation of agronomic experiments. An agronomic evaluation matrix identified constraints in production, and identified opportunities for increasing the productivity and competitiveness of both food and cash crops.

Following the trainings, farmers took responsibility for setting out their own experiments. Land allocation, planning and implementation of the trials, and evaluation were entirely community-led. Research questions arose in connection with new food and cash crops farmers opted to experiment with. Decisions regarding the prioritisation of food and cash crops were informed by both household and market demand. Over the three years, farmers conducted organic soil fertility management trials (to test management options suited to different soil and landscape conditions) and variety trials (testing selected food and cash crops). Farmers experimented with a wide range of food and cash crops, including ginger, garlic and onions as well as cassava mosaic virus-free cassava varieties. The experiments helped them to test crop varieties under specific sustainable agriculture practices, which included mulching, composting and the use of animal manure as organic fertilisers. Trials were also conducted to strengthen nutrient cycling and soil organic matter replenishment. All experiments were conducted on community learning plots, in most cases managed by the entire community.

Evidence from the research project in Hoima suggests that farmer participatory research is an effective approach for enhancing farmers' capacities to sustainably manage their agro-ecosystems. One farmer describes the benefits that arose from training in farmer participatory research as follows: "The things we started doing came through trainings especially on soil conservation because like us we have little soil, and so you find that you protect your soil from erosion, mulch to ensure water conservation, do not do burning, also advise your neighbours not to mismanage soil etc. and also plant trees so that you ensure nature protection. Those are some of the benefits. We also have some things we have sold together like soya bean which we collect as a group, and the buyer comes to buy from the group and you find that we get money as a group and people start even to admire you" (Individual interview I16 with Kugonza group[1]). This statement indicates that farmer participatory research does more than bring about ecologically relevant outcomes at farm level. Benefits from enhanced agro-ecosystem management are further translated into increased market penetration at group level. Altogether, this results in high recognition within their social environment which in turn feeds back into increased self-confidence for continued experimentation. Another study conducted in the same area confirms that experimentation has a positive effect on farmers' self confidence, which is further expressed in a high willingness among farmers to share their knowledge and skills on on-farm experimentation and act as multipliers through training fellow farmers (Prehsler 2010).

The ability of farmers to plan, implement and evaluate on-farm experiments are an indication of a new attractor. Farmers' experimental knowledge supports farmer-driven inventions and develops farming systems and procedures, identifies new approaches and appropriate technologies (Röling 2009a). The delivery of external, usually science-based, inventions is not comparable to the adoption of a farmer-developed add-on innovation. The latter is a dynamic, human pattern-disrupting yet short-term achievement, while the former is a complex learning process similar to obtaining a degree (Röling/Jiggins 1998).

Example

Pretty et al. (2006) report on a study of 286 interventions in 57 developing countries across the world where the impacts of various sustainability-enhancing agricultural practices were assessed: integrated pest and nutrient management, use of conservation tillage, aquaculture, water harvesting, agroforestry and integration of livestock in farming systems. In the 12.6 million farms that were studied, a net increase in crop productivity by 79% was observed along with an improvement in critical environmental services. Those projects dealing with adequate use of pesticides reported a 71% decline in their use, while increasing yields by 42%. The overall water-use efficiency increased considerably by enhancing soil fertility and reducing evaporation, using low-tillage techniques, improved varieties and inducing microclimatic changes to reduce crop water requirements. Annual gains of 0.35 t C per hectare in carbon sequestration potential offered new opportunities for households to generate income from carbon trading schemes. Within a period of four years, there was a dramatic increase in the number of farms (56%) and area (45%) that adopted sustainable technologies and methods, with poor households benefiting substantially.

With time, on-farm experiments gained momentum and translated into common day-to-day farming practice, being well-integrated into farmers' knowledge system. They helped farmers to develop an experimental culture towards more adaptive agro-ecosystem management. At the same time, dependencies on external service providers were reduced. Information about the ongoing community-led experiments spread to other communities, which resulted in spontaneous farmer-to-farmer exchange visits. On-farm experiments are not new, yet handing over responsibilities for planning, managing and analysing them from researchers to farmers is rarely practiced. The existence of such farmer-led experiments therefore resulted in various official visits by sub-county and district officials.

Anecdotal evidence also suggests that farmer participatory research activities changed the perceptions of actors outside the immediate framework. For example, the privatised extension service at local government level now considers farmer participatory research as an important method of improving technology co-development as well as transfer. At the same time, changes within the innovation system became significant barriers to the further scaling out of farmer participatory research processes (scaling out research findings or technologies was anyway not intended). Due to limited funds, the public agricultural research stations left the project team. Also the intervention as such had limited outreach to other farmers. The assumption that farmer participatory research would spread across communities could not be verified.

This is not surprising, because the spill-over effects of training programmes at community level may be greater for agricultural technologies that have short-term benefits, and which require some degree of coordination to be most effective. Direct involvement of households in programs and organizations that promote such technologies may be necessary to ensure technology diffusion throughout communities (Jagger/Pender 2003). A review by Shiferaw et al. (2007) highlights that an excellent option to ensure adoption and adaptation of innovations is to develop them iteratively, in collaboration with the farmer groups.

5. Conclusion

Sustainable agriculture requires flexible, self-organised responses by farmers to natural resource-related challenges. Research and extension methodologies to support sustainable agricultural development should therefore aim to enhance farmer capacities favourable to sustainable agriculture, rather than to achieve the adoption of standardized technologies. These capacities include sound ecological knowledge, observational, analytical and experimental skills, and an inclination towards collectively allowing farmers to make better, informed decisions for location-specific agro-ecosystem management (Van de Fliert 2003, 2006).

Irritation through challenging the attractor, as carried out through farmer participatory research, is one of the few non-instructive support measures with chances to enhance learning, invention and innovation. Support measures ensure a widening of famers' perspectives, i.e. an increase in options and opportunities. This draws on various sources of information and is a process of opportunity identification by farmers themselves. In the course of time, performance of interventions in the field of agricultural research, water management, natural resource management and integrated rural development depend on a mutual consent with local priorities and trends (Zoomers 2006).

Multifaceted explanations of poverty and uneven development in agriculture, more so now than in the past, heighten confusions and tensions and mask an adequate understanding of the process of putting 'development' into practice. Farmer participatory research does not address structural deficiencies within the world economic and political system. However, farmer participatory research does make use of the room for manoeuvre that farmers have towards more sustainable agriculture. Applied developed research helps to identify that room for manoeuvre and to support farmers in broadening opportunities. An innovation systems perspective helps provide understanding of how this can be used to develop new local action and to translate it into comprehensive spatial and temporal innovations.

1 Chair person of the marketing committee of the Tukonyerangane Organic Farmers Association, Kaitira 31.8.2010.

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Abstracts

Innovation is ultimately linked to the human desire to think about new and better things and to try them out in practice. In this article, we suggest farmer participatory research as an approach to foster community-

led innovation in smallholder agriculture in western Uganda. Farmer participatory research is a process of designing and implementing on-farm trials to test and further improve agricultural technologies and agronomic practices. For smallholder farmers who lack access to formal agricultural research and support services, farmer participatory research supports community-led innovation aimed at improving ecological sustainability agriculture.

Innovation ist mit dem menschlichen Wunsch verbunden, über neue und bessere Dinge nachzudenken und diese in der Praxis auszuprobieren. In diesem Artikel schlagen wir „partizipative bäuerliche Forschung" *(farmer participatory research)* als einen Ansatz zur Förderung gemeinschaftlich entwickelter Innovation in der kleinbäuerlichen Landwirtschaft Westugandas vor. Partizipative Forschung von BäuerInnen ist ein Prozess, in dem Experimente direkt in den Landwirtschaftsbetrieben entworfen und implementiert werden, mit dem Ziel, landwirtschaftliche Technologien und agronomische Verfahren zu testen und zu verbessern. Für KleinbäuerInnen, die keinen Zugang zu institutionalisierter landwirtschaftlicher Forschung und den damit verbundene Dienstleistungen haben, fördert partizipative Forschung gemeinschaftliche entwickelte Innovationen, die darauf ausgerichtet sind, die ökologische Nachhaltigkeit von Landwirtschaft zu verbessern.

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